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FieldLog v. 3.0:

User's Guide and Reference

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FieldLog Manual, Version 3.0

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PREFACE

Welcome to the FieldLog 3 Manual

A Field Data Management Program for Geologists

FieldLog is a software module that runs with AutoCAD, the premier personal computer and workstation drafting software program. Together they provide an extensive set of cartographic and data analysis tools for field-based geologists. FieldLog is designed to:

- Provide a consistent and efficient data-entry environment for all field data
- Provide a powerful yet flexible organization scheme for field data
- Extend the capabilities of field researchers by providing a simple search environment that enables them to ask questions about data in the field
- Seamlessly handle coordinate issues such as map projections and user grids
- Seamlessly integrate existing data sources both towards field research questions and building a final map product
- Simplify the problem of regional compilation by providing geological glossaries of terms that may be consistent between many projects
- Provide a painless export mechanism so that data can be passed on to other users or cartographic specialists for final map production

FieldLog delivers all of these functions, and many more, in an easy to use and efficient package. Furthermore, FieldLog provides long term benefits to users via:

- Simple and complete GIS export and data import capabilities
- Consistent interface and operation across multiple operating system platforms and between local and corporate databases

About AutoCAD

AutoCAD is primarily designed for the cartographic drafting of objects that are not specially located on the earth's surface. As a result, while many of its tools are useful for cartography, it has fundamental limitations when it comes to geological map construction. These limitations include:

- No support for real world coordinate systems
- Limited support for managing data external to the map
- No extensions for geological data handling

The first limitation is a reflection of AutoCAD's inability to accommodate for the curvature of the earth's surface. Most field projects cover large enough areas that this will introduce significant errors into a map. The second limitation has to do with AutoCAD's limited tools for managing databases attached to maps. The third limitation reflects the fact that AutoCAD is not tailored for geological data entry, query, or analysis. These problems are solved by having FieldLog provide tools for map projections, geological database management, and analysis.

Thus, AutoCAD makes a suitable foundation for field mapping only if projections and other geologic tools are built in. These form a significant part of FieldLog, as you will see in this introductory manual.

About This Manual

This manual covers the basic FieldLog system and includes a tutorial covering general use of the FieldLog system: installation, customization, and downloading, importing and exporting of data. It also contains notes on using AutoCAD for preparing maps.

Geographic Information Systems technology draws upon a wide variety of source fields, ranging from mathematics through cartography and computer science. As we cannot hope to cover all of this material in this FieldLog manual, attached is an annotated bibliography to key references for further learning about GIS.

We don't expect that FieldLog will be the final repository of all geological information you will collect. In fact, most users eventually migrate their data to a desktop GIS such as ArcView or MapInfo, or to a full GIS such as ArcInfo, for integration with remotely sensed data, geophysical and geochemical imagery, and so on. This manual briefly covers the export of data from FieldLog to other systems.

Organization of theTutorial

The chapters in the tutorial are quite short, and you should be able to find a topic by chapter title relatively quickly or by referring to the Table of Contents. Boxed information delivers details that the average user might not need to know. When in doubt, start reading the box and if you don't see the need to continue, stop! In effect, the boxes are appendix material that we've inserted into the text to elaborate on the text.

There are four sections in this manual:

- Section 1: Introduction and User Overview

  This section explains exactly where FieldLog fits relative to other software tools you may have used or seen, and what role it addresses in the organization.

- Section 2: Tutorial (Chapters 2 to 5)

  With geological field data and maps from a project in northern Manitoba, the tutorial gets you up and running with FieldLog quickly and efficiently.

- Section 3: Integration, Installation, and Customization

  This section covers the use of AutoCAD for map preparation, installation of FieldLog under AutoCAD 12, 13, and 14, and a brief introduction to customizing FieldLog to serve your specific needs.

- Section 4: Exporting and Importing of Data

  This section covers importing and exporting data as well as editing data through external databases.

Font Conventions

Text in courier font indicates a command that you type. For example, to log on to FieldLog:

Type `fl-logon,` then press Return.

Bold text in Times-Roman font indicates an action you can carry out using either your mouse and the pull down menus, or the keyboard. For example, to save a file:

Choose **File>Save** from the AutoCAD menu or type `save` at the command line and then press Return.

A Note On FieldLog Platforms

FieldLog currently runs only with AutoCAD for Windows and DOS. Currently supported versions include AutoCAD 12 for DOS and 12 through 14 for Windows 95 and NT. There are currently no plans to port FieldLog to other systems or to support AutoCAD 2000 and beyond.

There have been dramatic changes to AutoCAD across the supported platforms and we can't hope to cover all of the detailed differences. **This manual was written to explain the use of FieldLog 3 running with**

AutoCAD 12 for Windows. All screen captures are from that system. FieldLog's appearance is fairly constant across all the supported platforms, but the background window appearances may differ somewhat.

Differences between the AutoCAD versions that affect installation, setup, and database connectivity are covered in the installation notes.

Where there are significant differences between the functionality of different versions of FieldLog, we explain this in clearly labelled sidebars.

Acknowledgements

The authors wish to acknowledge the contributions of the many FieldLog users; without their dedication, patience, perseverance, and constructive feedback, FieldLog would not have evolved to its present state. It's impossible to list all those who have contributed in so many ways, but special thanks is due to the Ontario Geological Survey for providing funding and support for the initial development and use of FieldLog and to the Geological Survey of Canada for funding and supporting FieldLog's subsequent evolution. Rob Harrap initially developed the manual and Deborah Lemkow significantly assisted in the manual's upgrade. Finally, the authors wish to thank their families for often bearing the burden of FieldLog's development.

CHAPTER 1

Why Use FieldLog?

Introduction

What exactly is FieldLog and what can it do for you? Why is it worth the effort of taking a computer into the field and reading a manual such as this one? Where does it fit into the goals of mapping and exploration organizations? Why are most academic and industry geologists now using computer mapping technologies in their day-to-day work? In this chapter we cover these questions and introduce spatial information technology — traditionally called Geographic Information Systems (GIS).

Background

There has been a fundamental change in field mapping in the past decade as more and more mapping organizations, ranging from geological surveys through to prospectors, come to terms with three fundamental facts of life:

- Decisions are being made in shorter and shorter timeframes
- Decisions are being based on larger and larger datasets
- Decisions are being influenced by ever wider ranges of datatypes

Whereas field mapping and exploration decisions twenty years ago were often based on the personal knowledge of a single expert referring to one map and at most a few reports, many decisions now draw on diverse data from technologies such as digital geophysics, compiled geochemical atlases, remotely sensed data, and compiled geological maps available in digital form. These datasets, hosted on computers rather than in report and map format, are ever larger, and have already largely surpassed the ability to be used without information systems tools.

The transition was and continues to be sped on by the rapidly decreasing costs of both the software and compiled data sources; datasets that a decade ago would have been impossibly expensive are

now available at no cost across the Internet, and the number of available datasets is ever growing.

Desktop decision support tools have the potential to help with the facts of life listed above, if all of the data is compatible with these tools. In many businesses, decision support tools based on relational databases are completely interwoven with corporate structure and function, supporting tasks ranging from inventory control to market prediction. These tools directly respond to large datasets, rapid decision making reality of recent times. In many ways, these tools have *created* the current situation.

GIS tools are specialized decision support tools that handle data where spatial location is a significant part of the decision making process. In fact, traditional decision support tools are rapidly merging with GIS tools since most business, scientific, and governmental decisions *do* involve questions of location and spatial relationships.

In a typical mapping office, desktop GIS tools ranging from specialized geophysical and geochemical processing packages through to Internet-hosted data browsing tools are being used to make decisions faster, with larger and more diverse datasets. In many ways GIS tools define a new communications medium, since by hosting all of the critical information in an organization in one environment, they promote collaborative and cross-disciplinary decision making.

The down side of the use of GIS tools is that all data must be collected or reprocessed into a format compatible with the system. For many subdisciplines of mapping, such as geophysics and remote sensing, the data as collected is in fact digital, and so all that is required is reformatting into compatible, standard data structures. Other data, however, is principally analogue, and considerable additional work must be expended to capture this data into a GIS.

Geological field mapping data is a prime example of traditional analogue data that many organizations are now striving to capture, or in many cases, recapture, into GIS. If the geological field data is to be incorporated into the decision making process, the data must both be digital and be of consistent detail and quality to support the types of questions that facilitate mapping and exploration.

FieldLog addresses the issue of capturing field data directly. To understand what functionality it incorporates, we need to examine the field mapping process in more detail.

The Field Mapping Process

Geological mapping and research is fundamentally a problem of collecting *data* at various *places*, and then *manipulating* the information, directly or indirectly, either during the field season or after the season is finished, to produce a report which is almost always accompanied by a *map* and explanatory *graphics.*

Most field data that needs to be manipulated is located at a specific point in *space*, almost always on the surface of the earth, and most field data occurs as descriptive classifications, orientation data, and written notes. In a traditional mapping operation, the data is recorded in an analogue form in a notebook and when manipulation is necessary the geologist laboriously works through the notebook and produces a summary. The summary is often a thematic map keyed to illustrate some aspect of the data or a specialized diagram such as a stereonet

— a visual representation of data that allows general trends to be noted and conclusions to be drawn.

In fact, perhaps the last thing a field geologist really needs is to have a project's field data strewn through various notebooks, with each query concerning the data requiring extensive reading, notetaking, and manual summarizing on diagrams. All of these take time away from *mapping* and divert it to clerical duties. This is where a GIS can help.

The crucial balance that must be achieved is between the power of the GIS to aid in analysis and graphic production versus time spent entering data in the first place. There have been two approaches to the problem of using GIS to date:

- Collection of traditional analogue notes and then recapture into a GIS either in the evening or post-season
- Collection of digital notes on the outcrop, possibly using Global Positioning System (GPS) navigation to simplify location finding

FieldLog 3 supports both types of data capture. For recapture, it provides an interface whereby field notes can be added to project specific databases. It handles multiple projects simultaneously to simplify organization, and provides cartographic functionality through AutoCAD to draw a publication-quality map.

For digital capture, FieldLog supports importing field data from PDA (Personal Digital Assistants) handheld computers, such as the Apple Newton, and the direct import of tables captured in delimited format from GPS receivers. It also can be used directly in the field, running on a pen or mouse-based portable. The only limitation in this process is that the computer must be capable of running AutoCAD. To date this rules out using Windows CE-based palmtops to run FieldLog directly.

The advantage of digital capture over recapture is clear: by providing capture on the outcrop, the GIS is bound to be more complete, more consistent, and also may aid in the mapping process by allowing limited analytical work on the outcrop. By being captured direct to digital, time spent recapturing the data in the evening can instead be directed towards map production, thinking about the data, and carrying out analysis.

About Classification

When geologists examine a sample, or geological structure, they are fitting what they *observe* into a *classification scheme* based on their knowledge of geological methods and theory. Scientific terminology is a rigorous system for classifying observations in a way that allows unambiguous communication, at least as an ideal.

When categorizing an observation, there are two issues that become central: the consistent *use* of terminology by members of a mapping team and a consistent level of detail of classification.

Much of the query functionality and data entry tools in FieldLog are built around supporting consistent field observations so that the field mapping database will be as useful as possible. These tools, as a result, have explicit ways of dealing with terminology.

The Field Analysis and Cartography Process

Why AutoCAD?

FieldLog is a module that runs within AutoCAD. Why isn't it an independent program?

AutoCAD is a high end CAD program with hundreds of features and a thick set of manuals. It provides interactive drawing tools, support for digitizers and other specialized hardware, and handles the storage of spatial information internally. FieldLog adds only the specialized geological and GIS tools that are lacking in AutoCAD.

AutoCAD's drawing tools, layer support, linetypes, and hatching allow sophisticated maps to be produced quite easily. The combination of a colour inkjet printer, a laptop running FieldLog, a digitizer, and a word processor turns a bush camp into a map production studio!

Once consistent data is captured into a field system such as FieldLog, it's straightforward to carry out decision support analysis using the data. Typical questions asked of spatial data are:

- Locating subsets of the data that have specific characteristics...

  where are the granite outcrops? where are the steep structural fabrics? where are the mafic rocks that were sampled? where are the sedimentary rocks with known bedding orientation that also had tops determined?

- Locating subsets of the data based on location...

  isolate all of the stations that are in the northeast quadrant of the map for output to a more detailed map... find all structural measurements that were made within 1km of a specified fault zone... plot a stereonet of all structural measurements in an irregular area...

- Locating subsets based on complex combinations of characteristics and location...

  make a stereonet of all planar fabrics recorded in mafic volcanics within an irregularly defined zone, where the mapping was done by a specified geologist...

Since a spatial decision support system can handle most possible geological questions *in principal*, the usual limiting factor on analysis is the availability and continuity of suitable data. Consistency of terminology and detail is crucial.

FieldLog supports these type of analysis by providing a rigorous data model for the storage of the field information and by providing powerful database and spatial search tools to act on the stored data. FieldLog is capable of performing composite searches, including any of the types used as examples above, and returning the solution to the question as a table. Once inspected, the results can be dynamically displayed on the current map view, plotted as a thematic diagram such as a stereonet or rose diagram, exported to another desktop GIS tool, or archived to disk. FieldLog further supports naming the question itself, so that a library of common questions can be built up to speed analysis.

In addition to the ability to search and display results, the system must also be capable of handling cartographic design as required by a geological map. Advanced GIS tools can produce publication quality maps with ease — in fact, most modern maps are produced using GIS. At the level of field geology, needs are more modest, and the ability to draw polygonal areas, lines with variable linetype, and add text labels is often sufficient to make field maps. FieldLog supports cartography via AutoCAD using the traditional AutoCAD drawing tools to handle line, text, and polygonal area drawing, and extending AutoCAD greatly to handle the dynamic display of text, structural symbology, and descriptive data interactively between the field database and the current map.

Summary

FieldLog is a rudimentary GIS that stores geological information at points or related to linework. It provides projection, transformation, and export support, and has an intuitive and very powerful geological query mechanism that can create various geological diagrams.

FieldLog runs within AutoCAD, which provides excellent drafting tools for the production of final output maps and diagrams. Furthermore, AutoCAD is available on many hardware platforms, enabling you to use the combination of FieldLog and AutoCAD in situations ranging from a laptop in the field to a workstation in the lab.

CHAPTER 2

Starting FieldLog

Introduction

This is the beginning of the introductory tutorial to FieldLog. We assume here that FieldLog is installed and working, and that the sample data for the Snowlake tutorial project is installed. If this isn't the case, refer to Appendix A, *Installing FieldLog*, and then return here.

Because FieldLog is an extension to AutoCAD, you must operate it from within AutoCAD. In this chapter you learn how to:

- Log on to FieldLog
- Browse a sample database
- Log off FieldLog

Logging on to a FieldLog Database

Starting AutoCAD

Before you can log on to a FieldLog database, you must start AutoCAD and open a drawing. Refer to your AutoCAD manual for instructions on starting AutoCAD and opening a drawing.

In this tutorial we use *snowlake.dwg*, a map of the Snow Lake area of northern Manitoba.* This map has all of the common elements found in a geological field map — a topographic base, location information, geologic contacts, and a coordinate system.

* Bailes, A.H., and Galley, A.G., 1993, Geology of the Anderson-Stall volcanic-hosted massive sulphide area, Snow Lake, Manitoba: Geological Survey of Canada, Open File 2776, 1 map, scale 1:10,000.

Opening SnowLake.dwg

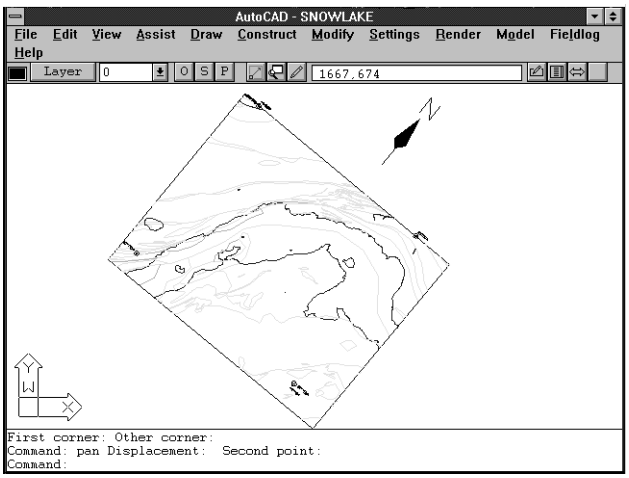
Snowlake.dwg contains the linework and cartographic annotation for the SnowLake FieldLog Database. Remember that FieldLog relies on AutoCAD to manage all the graphical elements of a map, while it adds the underlying database structure for storing geological field information associated with the map.

To open *snowlake.dwg*:

1. Choose **File**>**Open**.
2. Select *snowlake.dwg* from the *snowlake* directory (or where you installed the sample files).
3. Click **OK**.

   The SnowLake drawing appears.

The drawing is rotated relative to the screen by about 50 degrees clockwise. This is because the Snow Lake project is based on a user grid, and FieldLog understands and maintains the relationship between this grid and standard methods of projecting maps such as UTM. The user grid in this case is rotated relative to north, and note that the North arrow points off to the upper right on your screen. See Map Projections in Chapter 7 for more information.



Starting FieldLog

Problems loading a database

If you get an error during loading (e.g. ‘error 12’) it is possible that required AutoCAD components such as ASE -- external database connections -- are not installed.

During the installation process FieldLog established which projects are available on your machine. If no names are present in the pop-up list, the list of available projects was not read. This process of identifying projects depends on your version of AutoCAD. Refer to Appendix A for further information.

Now that you’ve opened a drawing, you can start FieldLog. You can do this manually or using the FieldLog menu. If you don’t see a FieldLog menu at the top of your screen, refer to Appendix A for installation instructions.

To start FieldLog:

1. Choose **FieldLog**>**Load FieldLog**.

   A message in the AutoCAD command line indicates that FieldLog has loaded. Now you’re ready to log on to a specific database.

Logging on to a Database

Each time you open FieldLog you must indicate which database(s) you want to use. Several databases can be active at one time, enabling you to compartmentalize a project into several independent sub-projects or display adjoining project data on one map. See Chapter 7 for more information about project setup.

To log on:

1. Choose **FieldLog**>**fl-logon**

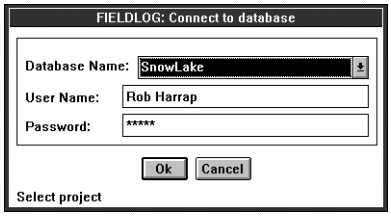
R13-R14 Note

When logging on in AutoCAD R13 and R14, only projects not already logged-on are available in the pop-up list.

Symbol Errors

In some cases symbol libraries fail to load properly. If this occurs, simply click OK to continue. This may mean some symbols may not be available to you when plotting or inputting data.

The Connect to database dialog box appears.



If you were logging on to a corporate database, you would need a user name and password. Because the demo files are local and unprotected, you can leave the *User Name* and *Password* fields empty.

2. Select *SnowLake* from the Database Name pop-up, then click **OK**.

   FieldLog begins loading the project description, including the list of tables in the database, symbol specifications, coordinate systems, saved database queries, and so on. When FieldLog finishes loading the SnowLake database, it returns you to the standard AutoCAD command prompt.

Now that you've loaded an AutoCAD drawing, FieldLog, and a sample database you are ready to browse the database.

Browsing the SnowLake Database

Relational Databases

Relational databases organize information in tables. Each table can have multiple columns, or *fields*, and any reasonable number of rows, or *records*. Fields have a data *type*, meaning that a field might store a date, an integer, a logical (true/false) value, or a string of characters.

FieldLog can store information in many database formats through the use of external database drivers such as ODBC or those provided by AutoCAD. FieldLog also provides its own enhanced dBase III driver.

A fundamental operation in FieldLog or any other GIS involves asking a question, then analysing the answer. Normally GIS queries either return a list of valid data that satisfy the question, or else a map showing this data. In FieldLog, queries return their results in a query table, which can then be surveyed visually, edited, plotted or exported to a wide variety of formats, including to the displayed map. This section provides a brief overview of the query process using the SnowLake database.

To optimize storage and access of data, FieldLog stores all data in **relational databases**. Browsing data stored in relational databases is simply a matter of asking FieldLog to extract some of the information from the database into a table, which looks very similar to a spreadsheet display.

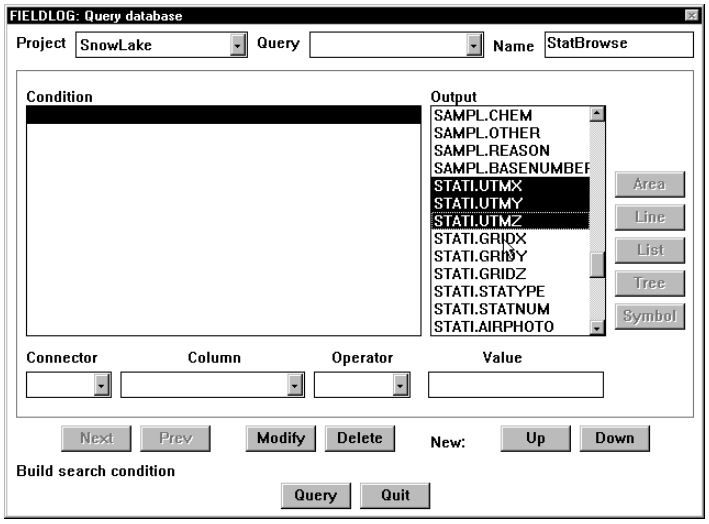
To start the query process:

1. Choose **FieldLog>fl-query**.

   The Query Panel appears (see below). The query command lets you quickly review your database, as well as create complex, multipart queries and output the results in varying ways, including to other programs.

2. Choose *SnowLake* from the *Project* pop-up. Remember that FieldLog allows you to have a number of separate projects running, attached to a single map.
3. Type `StatBrowse` in the *Name* box.

   Naming the query allows you to rerun it at a later time simply by picking its name from the Query pop-up. This can save considerable time when re-using complex queries.



Error Messages

Three common situations result in error messages during the FieldLog query process:

- If there is no corresponding data in the database, FieldLog returns a no data error. This doesn't indicate a true problem.
- If the query returns a column name that is reserved by AutoCAD, FieldLog returns an error.
- The number of records that FieldLog indicates were found during the query process is often incorrect because the calculation indicates an interim total, calculated before the final query is complete. This is an unavoidable limitation of the AutoCAD database environment.

Tables in the SnowLake database include *STATI*, the station table, *STRUC*, the structural table, *LITHO*, the lithology table, and so on, representing data typically recorded at a field site. Each table is independent, but can be *related* or *joined* to the others to build a complex query. Here all we want to do is look at an unfiltered portion of the database — we don't want to look at the *entire* database, just few of the fields from two tables. This is achieved by selecting some of the database columns from the *Output* list. Because no further constraint is placed on the database, all the occurrences of data from those columns are returned as rows in the result table. This amounts to building a quick summary of your field database and is analogous to asking the question 'show me all the data' stored in the specified fields.

4. Choose the following from the *Output* list:

   LITHO.ROCKNUM

   LITHO.ROCKTYPE

   STATI.UTMX

   STATI.UTMY

   STATI.UTMZ

   These correspond to a numeric identifier for each lithology at a station, as well as a rock name, from the *LITHO* table, and a station location from the *STATI* table. You can select and deselect entries on the list with successive mouse clicks.

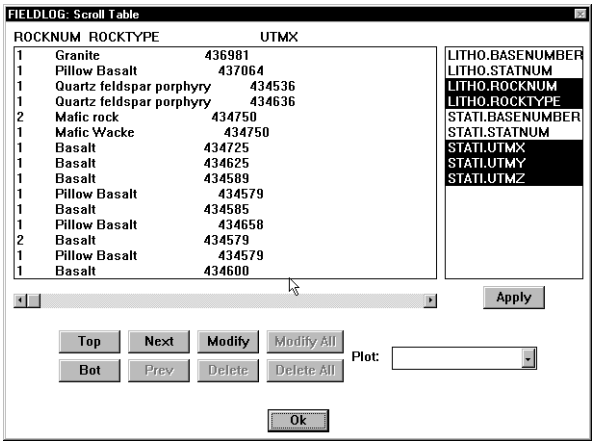
5. To run the query, click **OK**.

   A message box appears indicating that FieldLog is running the query. When the query is done click **OK** to display the query results where you can use the Scroll Table dialog box to quickly view large amounts of data.

6. Click **OK.**

The Scroll Table dialog box appears.

Note that the columns in the table aren't aligned. This can happen if your Windows system font isn't set to a fixed width spacing. Fixed width spacing is possible in DOS and Windows 3.1 but not in Windows 95/ 98/NT environments



Try navigating through the table:

- Use the *slider* to view data off of the right side of the table.
- Click **Next** or **Prev** to scroll up or down.
- Click **Top** or **Bot** to jump to the top or bottom of the scroll table.
- To close the Scroll table, click **OK**.

About FieldLog Data Tables

R12 Note

FieldLog sorts single-table queries according to basenumbers and multiple table queries according to data values such as station numbers.

R13/14 Note

All results are sorted according to a data value such as station number.

Although many of the entries in the data tables, such as station numbers, may at first seem redundant, these entries are the key to FieldLog's power.

Each table contains a column which stores a unique numeric identifier for each row in the table. In the SnowLake database this column is called *basenumber* and it unambiguously identifies individual records (rows). These unique values allow FieldLog to unambiguously separate what might otherwise be identical records.

Data is spread between many tables for flexibility and data integrity, but the tables are related by common column values. For example, rather than repeating station level information, such as station location or field date, for each lithology in *LITHO*, FieldLog uses the *STATNUM* value found in both tables to relate station information indirectly. If you have four lithologies at one station, this means you only have to enter station information once! The organization of a database into small tables to reduce redundancy is called database normalization.

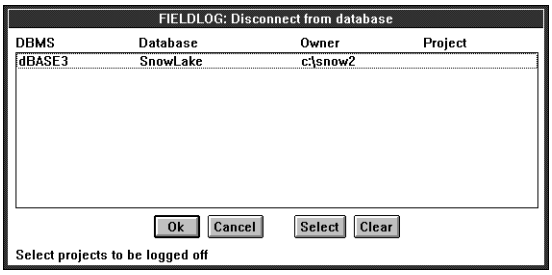
Logging Off

When you're finished using a FieldLog database, log off the database. This allows FieldLog to terminate any connections to external databases and close down internal connections clearly.

1. Type `fl-logoff` in the AutoCad command line or choose **FieldLog>fl-logoff**.

   The Disconnect from database dialog box appears.

2. To select the *SnowLake* database, click it, or click *Select.*
3. Click **OK**.



Ending an AutoCAD Session

Database activity isn't affected by the *File>Save* process, as all database manipulations are **immediately** saved on execution.

If its configuration has been changed, FieldLog also saves changes to its setup during the *File-Save* process. Simply clear the resulting message to continue saving.

To save your drawing and exit AutoCAD:

1. Choose **File>Save**. Remember that FieldLog automatically saves your field observations in a database, but all associated map graphics are stored in an AutoCAD drawing *.dwg* file that must be manually saved. If you don't save the AutoCAD drawing, you lose all graphics that you added (or changed) during your FieldLog session.
2. Choose **File>Exit AutoCad**.

Summary

In this chapter, you learned how to:

- Start AutoCAD
- Open a Drawing
- Start FieldLog
- Log on to a FieldLog database
- Browse a FieldLog database using the fl-query command
- Log off
- Save an AutoCAD drawing
- Exit AutoCAD

AutoCAD Novices

If you're new to AutoCAD, you might want to read Chapter 6, *Map Preparation with AutoCAD*, before continuing the tutorial.

CHAPTER 3

Adding and Editing Data in FieldLog 3

Introduction

In Chapter 2 you learned how to start FieldLog, log on, and log off a FieldLog database using fl-logon and fl-logoff. You also reviewed one section of the sample SnowLake database using fl-query. The key points in Chapter 2 are that databases are external to an AutoCAD drawing, which means you need to connect to them explicitly, and that the database consists of tables that you can browse, edit, and perform sophisticated queries on.

Building a GIS database is about more than simply browsing records using queries. In this chapter you'll discover what's involved in adding data to an existing database. The process you'll learn in this chapter is very similar to the one you'll perform at the end of a day's field work or during data recapture, if you choose to use FieldLog to capture notes from maps and field notebooks.

In this chapter, you'll learn how to:

- Add data to an existing FieldLog table
- Edit existing data
- Interactively move data on the graphics screen

Before You Begin

If you aren't logged on to FieldLog and the *SnowLake* database, follow the steps from Chapter 2 to open *snowlake.dwg*, start FieldLog, and log on. Remember that you need to load FieldLog before you can logon.

Adding Data to a Table

The FieldLog Data Model

The way that FieldLog decomposes field data into distinct tables is called the FieldLog *data model* (more on this in Appendix B).

In brief, the tables mirror *kinds* of information recorded during a fieldwork session. Traverses are about *the days work.* Stations are *places where observations happen.* Lithologies are *rock types seen at a station.* Structures are *structural features seen or measured at a station.* Samples are *specimens collected to match observations, and include such things as rocks, soil samples, and photographs.*

The overall database structure thus reflects the field mapping process. By breaking things into tables, long-term clarity is enforced and the ability to manage large data sets is enhanced.

Each time you add field data to an existing database, you work with a number of different tables. For example, after each traverse you'll probably add:

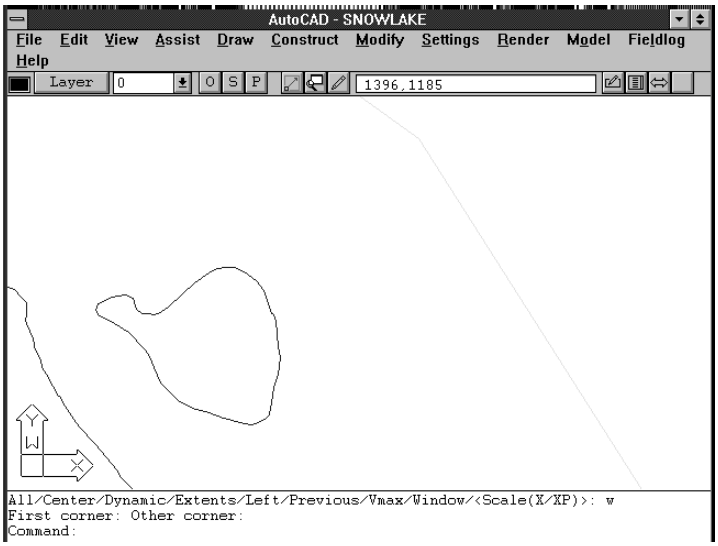
- A new traverse description to the *TRAV* table
- New stations to the *STATI* table
- One or more lithologies observed at each station to the *LITHO* table
- One or more structural measurements per station to the *STRUC* table
- A record of all photographs taken at each station to the *PHOTO* table
- One or more samples to the *SAMPL* table

As briefly noted in Chapter 2, FieldLog manages field data in a relational database. Each of the different tables in the database are *related* to build one coherent database — see the side bar for a thematic overview. The subdivision of data you enter into the tables reflects the internal organization of the database, which reflects the overall structure of fieldwork. As you will see in Chapter 7, you can customize this organization to meet your needs.

Let's assume that you've done some mapping in the Snow Lake area and are ready to enter some new data to the *SnowLake* database.

Getting Ready

First, use AutoCAD's zoom command to zoom in on the island on the east side of the map. When you're done, the island should fill about a tenth of your screen.



Now you're ready to add the following field geological information to the *SnowLake* database:

- A new traverse
- Two stations on the island
- Lithologies for each station
- A sample at one station

- A photo at the other station
- Structural measurements at both stations

As you add the new data, note that you first enter the data into the database, then on the map. FieldLog setup allows you to specify what database details appear on the map during this data entry process. As well, any query you run can output to the AutoCAD map, so you can always dynamically add more map symbols and text later.

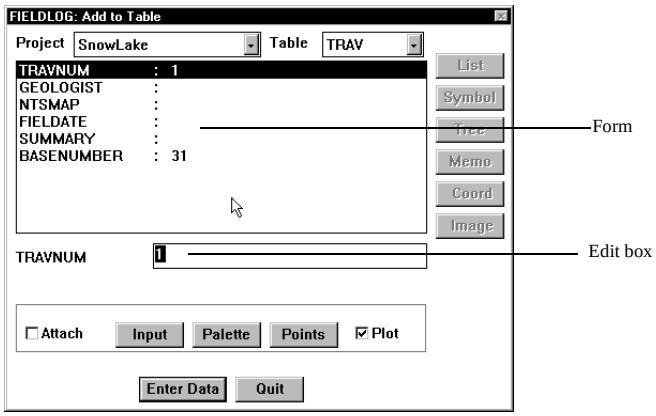
Adding a New Traverse

1. Type `fl-add` or choose **FieldLog>fl-add**.

   The FieldLog Add to Table dialog box appears.

To shift between rows in the forms section, point using your mouse/digitizer or press the Return (Enter) key.

If you shift to a field that requires a value, you won't be able to move away from that field until you enter a value.



2. Select *SnowLake* from the *Project* pop-up.
3. Select *TRAV* from the *Table* pop-up.

   Now that you've chosen to add a new traverse to the database, FieldLog displays the possible data fields associated with the traverse in the Add to Table form. This is a data entry form for filling out FieldLog's tabular information. By providing a rigorous data entry form, FieldLog supports uniform detail in a database.

R13/14 Note

In R13 and R14, the first project on the list will be automatically selected.

In R12, you must manually select the project each time.

4. Select *TRAVNUM*. Type `29` in the edit box at the bottom of the screen, then press Enter.

   If the entry is valid, FieldLog selects the next item in the table. If the entry is invalid, a message appears at the bottom of the Add to Table dialog box.

5. For *GEOLOGIST* type `ME` in the Edit box, then press Enter.

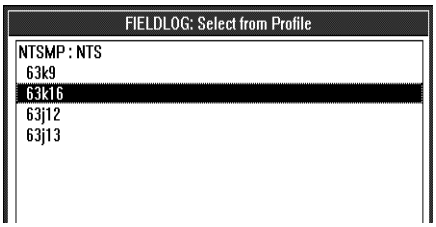
   Normally you'd type your initials here, but we don't know your initials, and we need these later for a query. Note that if you try to enter a long name here, FieldLog returns an error. In the setup of the SnowLake database, this field was deliberately kept short.

6. For *NTSMAP*, click **List** (the top right most button).

Why Have a Traverse Table?

During a typical data entry session you add data for one day of mapping or one traverse. Why bother explicitly keeping track of traverses? This simple once-a-day entry enables you to do sophisticated queries — such as displaying mapping done by one geologist or mapping done after a certain date.

The Select from Profile dialog box appears, listing possible values.



7. Choose *63k16*, then click **OK**.
8. Once you're back in the Add to Table dialog box, press Enter.
9. For *FieldDate*, type `19960621` (or today's date), then press Enter.
10. For *Summary*, type `Quick tour of island`, then press Enter.
11. To add the record to the traverse table, click **Enter Data** at the bottom.

    FieldLog assumes that you'll be adding more traverses to the database, so it increments the traverse number by one and returns you to the Add to Database dialog box.

    If you want to enter data to another table, you can easily change tables using the Table pop-up.

12. When you're finished adding data, click **Cancel**. This doesn't cancel the entries you've just made, it simply ends your current data entry session.

Adding New Stations

About Space

Location on the surface of the earth is specified using a coordinate system. In Canada, the two common methods used are geographic coordinates (or latitude/longitude) and Universal Transverse Mercator (or UTM). UTM is a map projection or a method of transforming locations on a globe to a flat sheet with a minimum of distortion.

FieldLog can convert between most major projections and can simultaneously record locations into multiple projections, automatically converting between them as data is entered.

The SnowLake database is an example of where two coordinate systems are used — the map is stored in a user grid coordinate system and the positions are transcribed into UTM.

When adding a new station to a FieldLog database you must enter the station coordinates — after all, the key to a spatial database is that it records not only descriptive information (usually called attributes) but also spatial location. You can enter coordinates by:

- Typing in the actual numeric value (in the current projection system)
- Pointing with a digitizer or mouse to the station location on the screen
- Pointing with a digitizer or mouse to the station location on a map or air photo secured to a digitizing tablet (you must first calibrate the map or photo to the AutoCAD map — see *Tablet Calibration* in Chapter 6)

During actual field work you might be digitizing the location from a calibrated airphoto, grabbing the data from a hand held computer or GPS, digitizing from a sketch map, or visually comparing a sketch on the screen with a paper map. For simplicity, we'll use this final method here.

In this lesson you'll learn how to locate a station by interactively choosing a point on the screen. This is the least rigorous of the methods allowed because the location will be specified via approximate visual placement.

1. To open the Add to Table dialog box, type `fl-add` or choose **FieldLog>fl-add**.
2. Select the *SnowLake* project and the *STATI* table.
3. Leave the *UTM* and *GRID, x, y, and z* values blank.

If the *UTM* or *GRID, x, y, and z* contain values, you won't be able to interactively select a point. FieldLog assumes that because you left them blank, you want to pick the location interactively.

4. Select *STATNUM,* type `me1`, then press Enter.
5. For *AIRPHOTO*, type `none`, then press Enter.
6. For *TRAVNUM*, type `29` (since this was the last traverse number you entered, it should by default already be in the table).
7. Click **Enter Data**.

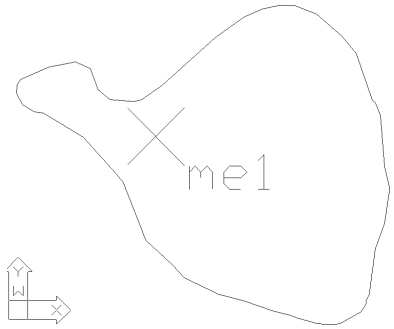
   The dialog box disappears and a crosshair with the station symbol and number appears on the map. If your digitizer was calibrated and you had a station on map or airphoto to enter, you would now align the digitizer cross-hair with the station or the digitizer and click. Here, though, you'll work in a relative mode, by visually estimating a location.

8. Move your mouse or digitizer until the crosshair is on a point at the left side of the island (southwest side), then click to place the data.

   Note that the station number is automatically positioned beside the symbol. (Remember, during setup you specify what database information appears on the map and what information is simply stored in the database. For more information on symbol setup, see Chapter 7, Customizing FieldLog).

   FieldLog returns you to the Add to Table dialog and automatically increments *STATNUM* by one. Because FieldLog assumes you'll be quickly adding blocks of data, it defaults to the next station number.

   After the station has been entered, the map should look like the one shown below. To view the map you can close the fl-add panel by clicking *Quit,* or by dragging the panel to one side using your mouse.



Why a Key Number?

If FieldLog included rock descriptions as part of the STATION table, you would have to make assumptions about data collection during database setup. How many rocks, at most, would you leave room for in the STATI table? Any unused fields would still occupy space in the tables, so your database would be highly inefficient.

By keeping rock descriptions in a separate table, the LITHO table, any number of rock descriptions can be entered. Each description represents one row in the table. Each is uniquely identified by the combination of a station number and lithology code. The lithology code could be a sequence number, representing the 1st, 2nd, 3r... lithology at the station, or it could be a code from a geological legend (e.g., 2a).

Adding Lithology Data

Now we'll add lithological information for the newly created station. Once again, we do this using fl-add.

1. If the fl-add panel is not displayed, open it using the menu or the command line.
2. Select the *SnowLake* database and the *LITHO* table.

   Notice that the station number is already correctly filled in and we can begin by adding the Lithology. Note that there is a key number for the rock number. Accept the entry of *1* here and move to the *Rocktype* field:

3. With *Rocktype* highlighted, click **List** on the right.

About Depth

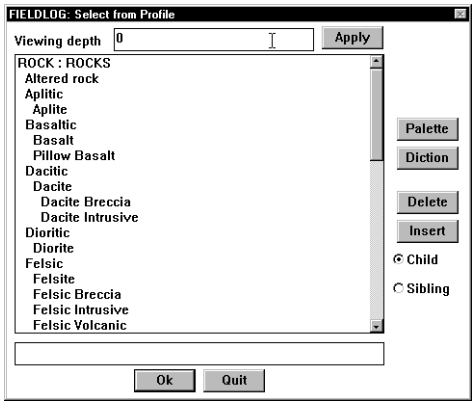
The Profile Browser contains a viewing depth field and an Apply button. What are these for?

Geological classification schemes are, mostly, hierarchical. For instance, we subdivide rocks into igneous, metamorphic, and sedimentary classes. We subdivide igneous rocks into felsic intermediate, mafic, and ultramafic. The exact level and type of subdivision reflects the specific interests and goals of the mapping geologist. Most geologists can agree on the division and subdivision terms for rocks, but sub-subdivisions and so on quickly become highly personal terms.

FieldLog is unique because it allows geologists to express queries in geologic terms. To a great degree this comes from FieldLog's use of profiles. The FieldLog profile allows a query to specify, for example, all igneous rocks without naming them all — the subdivisions *know* their division (e.g., granite *knows* it belongs to igneous rocks).

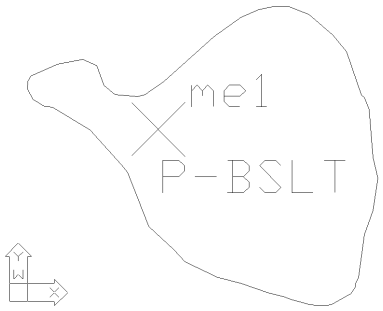
The Viewing Depth box allows you to specify how deep into the profile hierarchy you see. A 0 shows the entire hierarchy, a 1 only the divisions, a 2 the division and subdivisions, and so on. Viewing depth can be useful when you want to scan the entire profile without getting overwhelmed by details.

The Select from Profile browser appears.



4. Click *Pillow Basalt*, then **OK**.
5. Interactively place the lithology code on your map by pressing **Enter Data** and positioning the lithology code on the map.

   FieldLog returns you to the add panel.

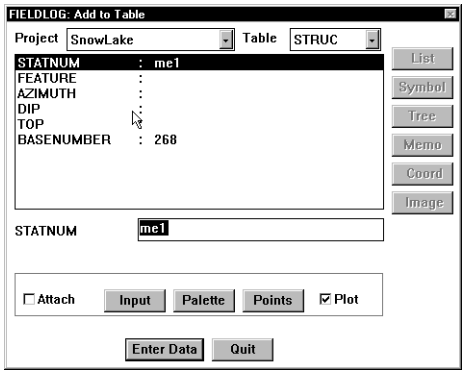


6. You're finished adding lithology information. To exit, click **Quit**.

Adding Structural Data

Next you'll add some structural data.

1. Open fl-add, then select the *STRUC* table.



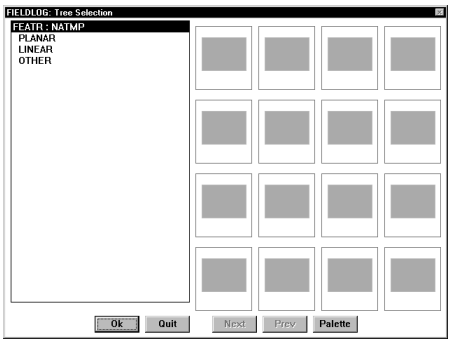
   Notice that the *Statnum* is already filled in. Because the *STATI* table ties station *me1* to traverse *29*, future queries could search for structures observed on a specific traverse.

Just as the profile for rock types keeps track of rock types hierarchically, FieldLog can be set up to store structural symbols hierarchically — planar versus linear, bedding versus foliations, and so on.

Now we'll use the structural browser to pick a first-phase foliation from the selection offered.

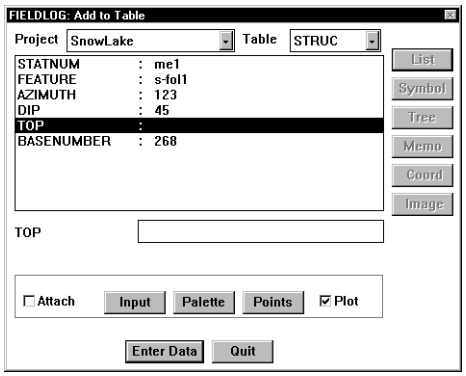
2. Click the *Feature* field, then the **Tree** button.

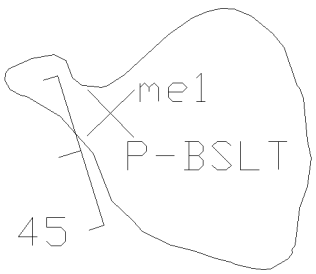
   The Symbol Tree browser appears.



3. Click *Planar,* then *Foliation,* then *s-fol1,* and click **OK**.
4. To add the chosen symbol to the table, press Return.
5. Enter `123` as the azimuth, and `45` as the dip.

   Your browser should look like the one shown below.





6. Click **Enter Data**, then place the symbol on the map.
7. Your map should look similar to the one shown at the right.
8. To exit the Add to Table dialog box, click **Quit**.

Congratulations, you've successfully added a station, a lithology, and a structural measurement to the FieldLog database.

Adding a Sample to Station *me1*

For practice, and to illustrate a few other features of FieldLog, we'll now guide you through entering some more data to the map.

1. In the Add to Table dialog box, select the *SnowLake* database and the *SAMPL* table.

To Plot or Not to Plot

Remember that when you add data to FieldLog you're primarily building a database, not drawing a map. A few well-structured queries can plot anything from the a database to the map at any time. Don't get preoccupied with what you do or do not initially plot to the map! When in doubt, reduce clutter on the map by keeping data in the database only.

2. Enter the data in the Add to Table dialog box according to the values listed below:

STATNUM	`me1`	
ROCKNUM	`1`	
SAMPLENUM	`1`	(for this station)
THIN	`N`	(no thin section)
STAIN	`N`	(not stained)
CHEM	`N`	(not chemically analyzed)
OTHER	(leave blank)	
REASON	`to assay`	

3. Before finishing, click the *Plot* box to empty it. This allows data to be placed only into the database and not on the map.
4. Click **Enter Data**.

You've added a sample to the *SAMPL* table. Note that you didn't have to enter a location — the database assumes the sample coincides exactly with its station.

R13-R14 Note

In AutoCAD R13 and R14, it is possible to preview raster images stored in TIFF, Targa, and CompuServe GIF (R13 only), and Windows Bitmap (R14 only) formats. To do this, a column is designated as an image column using *Input Setup* and FieldLog then interprets the text as a filename. The text is entered during *fl-add*. The image is displayed when the user clicks on the Image button during editing, and is hid when Enter is pressed. If no path is specified in the filename, FieldLog looks in the project directory for the image file (e.g., c:\snowlake\rocks.tif). If a relative path is specified, FieldLog looks relative to the project directory (e.g., c:\snowlake\images\rocks.tif). Using an absolute path, FieldLog looks in the specified place (e.g., c:\images\rocks.tif).

This allows you to store references to digital photography, sketches, and other raster images in the database and to display them using FieldLog.

Adding a Photograph Caption to the Photo Catalog

In the Add to Table dialog, select the *SnowLake* database and the *PHOTO* table.

1. Enter data into the Add to Table dialog box according to the values listed below:

STATNUM	`me1`
ROLL1	`1`
FRAME3	`12`
CAPTION	`Interesting feature in outcrop`

2. Again, make sure the *Plot* box is clear.
3. To add the station, click **Enter Data**.
4. When FieldLog returns you to the Add to Table dialog box, click **Cancel** to return to AutoCAD.

For more information on photo captions, see Editing a Photo Caption.

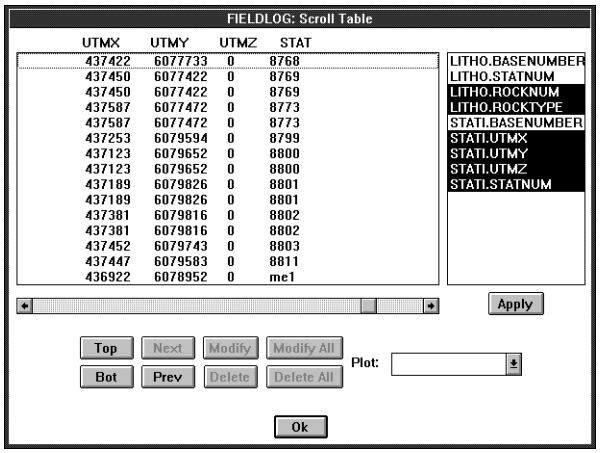
Using Fl-query to Check a Station's Values

We'll now check to see if you're adding the data correctly by using FieldLog's fl-query command.

1. Type `fl-query` or choose **FieldLog>fl-query**.
2. To rerun your StatBrowse query, pick it from the list, then click **Query**.
3. To move to the bottom of the list, click the **Bot** button.

Notice how easy it is to run a saved query. As you continue to use FieldLog, get in the habit of naming any queries that might be useful later. Give them descriptive names so you'll remember what they do.

Note that *me1* is now in the list along with *UTMX*, *UTMY,* and other attributes you added earlier.



Adding Information To Existing Stations

You can go back at any time and add or modify information at existing stations. In this section we'll add another structure measurement — a lineation — to *me1* and force it to remain hidden. Hiding information is useful when you want a complete database, yet don't want your map to be too crowded.

1. Start fl-add using the menu or AutoCad command line.
2. Choose the *STRUC* table. To change the current station to *me1*, select *STATNUM*, type `me1`, then press Enter.
3. For *Feature,* click **Tree**.

   The Tree Selection dialog box appears.
4. Click *Linear,* then *L-Fabric*, then the *lu* symbol.

   FieldLog returns you to the Add to Table dialog box.
5. Press Enter.
6. For *Azimuth*, type `45`, then press Enter.
7. For *Dip* (plunge in this case), type `30`, then press Enter.
8. Clear the *Plot* checkbox, located at the bottom right of the dialog box.

   ☐ Plot
9. Click **Enter Data**.

FieldLog adds the value to the database, but not to the map. You can now use the fl-query command to check whether the information was entered correctly into the database. Try it!

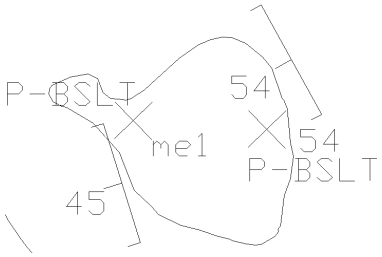
Exercises

Before going on to more advanced topics, take a moment and do the following exercises.

- Add a station, *me2,* at the other end of the island (use the same date, map, and so on, as for *me1*)

- Add a lithology, *pillow basalt*
- Add a foliation (*s-fol1*) with strike *111* and dip *54*
- Add a sample, *for assay*

Make sure you toggle *plot* back on so that the data ends up on the map. When you are finished the map around the island should look similar to the one shown below.



Editing Data

Whether you want to correct mistakes or refine interpretations, you can edit any data in a FieldLog database. In this section you'll edit some of the data you just entered into the *SnowLake* database.

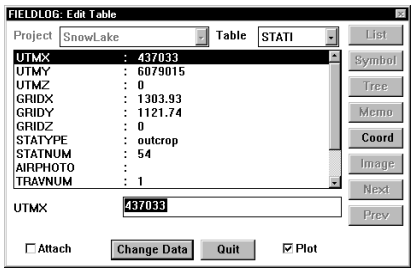
There are two principal ways to access FieldLog data for editing. If the value you want to edit is tied to a visible object (a structural symbol, a station marker, and so on), you can edit the value using **fl-move** or **fl-edit** by simply invoking the command from the menu or command line and clicking on the object on the screen. If the value isn't visible, first find the data using **fl-query**, highlight the row you want to change or add to, then click **Modify** to change its value. We'll start by moving an existing station.

If FieldLog isn't running and you aren't connected to the SnowLake database, follow the steps from Chapter 2 to open *snowlake.dwg* and log on to the database.

Editing a Station's Location

If you get this message, try selecting the entity again. You may not have selected the entity correctly or you may have selected an entity that doesn't contain any FieldLog information.

Try using *fl-edit* to inspect a station. Note that the station has coordinates that were captured from the mouse interactively.



Moving a Station

After entering station *me2*, you realized that you placed it in the wrong location. You want to move it a few meters up the right side of the island. If this were

simply an AutoCAD entity, you could use the *move* command or drag the object dynamically. However, since it's a FieldLog station, you must move not only the graphic representation of the object on screen, but also the coordinates stored in the FieldLog database.

About Object Selection

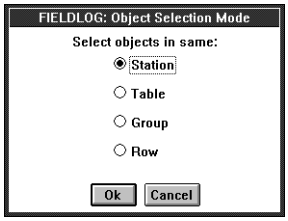
When you decide to move an object on the map, there's some ambiguity about what you're trying to accomplish. You might want to:

- Move all data associated with a station (STATION)
- Shift all data associated with a table by an offset from the station location — this is useful for placing structural data beside stations rather than on top of them (TABLE)
- Move only a selected database entry from a single table (ROW)

To accommodate all of these possibilities, FieldLog displays the Object Selection Mode dialog box whenever you use fl-move.

1. Type `fl-move` at the AutoCAD command line.
2. Select the station symbol (the X) for station *me2*, then press Enter.

   The Object Selection Mode list box appears. You can use this list to select all items in the same station, table, group, or row.
3. To move all data associated with the station, select the Station radio button.



4. Click **OK**.
5. Drag the station and all associated data to a new location on the right side of the island.
6. To place the station in its new location, click.

   That's it! Note that all the lithology and structural data followed along.

Moving a Row

Navigating Tables

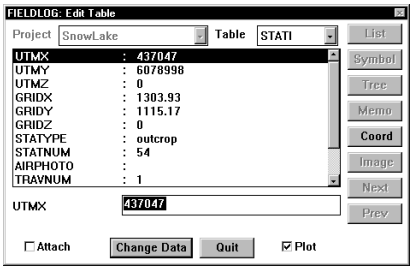
Notice that once you have selected *me2* the *Table* pop-up list remains available. In FieldLog you can navigate to any table related to the currently selected fl-edit item. Once you're finished editing the second table, using *Change Data* saves your edits and returns you to the previous table. *Quit* cancels any edits and returns you to the previous table.

Occasionally, when you move a station some of the station information, such as structural symbols, may obscure other objects in your view. To move the structural symbol for *me2*:

1. Type `fl-move` in the AutoCAD command line.
2. Select the structural symbol for *me2*, then press Enter.

   The Object Selection Mode dialog box appears. In this dialog box, you can select items in the same station, table, group, or row.
3. To move all data associated with the structural symbol (a row in the *STRUC* table), select the Row radio button.

   This limits the changes you make to the selected structural symbol and its associated text representing the dip or plunge.
4. Drag the symbol and dip to a new location.
5. To place the symbol in its new location, click.



R13-R14 Note

In AutoCAD R13 and R14 you can navigate and display up to four tables from the original fl-edit table. In R12 you can only navigate and display one additional table. Note that changes made to the navigated tables aren't applied to the map, as only the database is modified.

Limits on Modifying Tables in R12/R13/R14

If you use *fl-query* in R12 you'll notice that the modify buttons are often greyed out when you arrive in the Scroll Table display. In other words, you can't modify any of the data on the display.

This is due to a limitation in AutoCAD's support for the Structured Query Language (SQL), around which FieldLog is built. AutoCAD only allows edits when all displayed data comes from a single table. Notice in the photo editing exercise we only select items from the photo table — all of the entries are prefixed by *PHOTO*. If we had selected any entries from other tables — for example, *STATI.STATNUM*, we wouldn't be able to modify the data in the table because the scroll table would contain items from more than one table.

In R13 and R14, on the other hand, all scroll tables are modifiable.

R13/14 Note

Digital photographs may be viewed if the column in the *PHOTO* table contains the filename and if the *Image option* is set under the *Input* button.

This activates the *Image* button which displays the photo when clicked. Press *Enter* or *ESC* to clear the photo.

6. Use fl-edit on the moved station to verify that the position has indeed been updated in the database, as shown above.

Editing a Structural Symbol using Fl-edit

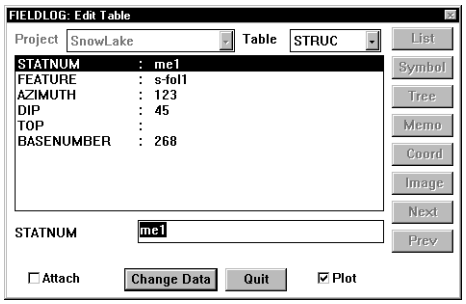
Now let's change the dip of the structural symbol at *me2*.

1. Type `fl-edit`.
2. Select the structural symbol at *me2*.

   The Edit table dialog box appears, listing the structural data for the selected symbol.

3. Select *DIP*, then replace its current value (`45`) with `55`.

   Your edit panel should look similar to the one shown below.



4. Click **OK**.

Your map should now show the changed value of 55. Note that with fl-edit you can interactively edit all aspects of a structural measurement or any other database content associated with any map entity created by FieldLog.

Editing a Photo Caption with Fl-query

Next let's edit the photo caption at *me2*. Because the photo isn't shown on the map, use the fl-query command to access and then edit the caption.

1. Use fl-query to select all stations with *PHOTO.STATNUM > 0*.

   From the selection list choose the following:

   PHOTO.STATNUM

   PHOTO.ROLL

   PHOTO.FRAME

   PHOTO.CAPTION

   PHOTO.BASENUMBER

2. Run the query.
3. When the Scroll Table appears, click **Bot** to move to the bottom of the table.
4. Select the *me2* entry, then click **Modify**.
5. Select the caption, then replace the current text with `Fascinating structures at me2`.
6. To exit, click **OK**. Note that the entry has changed.

That's it for adding and editing! Save your drawing and log out of the SnowLake database.

Summary

In this chapter you learned how to:

- Add new data to an existing FieldLog database
- Move data interactively on the map by item, station, and table
- Edit values in the FieldLog database by selecting them on the display
- Edit values in the FieldLog database by selecting them with a query

The ability to add data to a database by interactively working on a (screen) map is an effective way to capture data from analogue field notebooks or to recapture historic data. Many field geologists are finding, however, that it's more effective to capture the data digitally in the field, and then simply import the captured digital data directly into a database in the base camp. This is covered in Chapter 8.

Editing is an essential part of day to day usage of any field data capture system. Editing inevitably precipitates organizational difficulties when working on larger projects — who has the right to change data? Furthermore, databases that are hosted on multiple machines can quickly become internally inconsistent if great care isn't exercised.

Exactly what is entered and the organization of the database itself is an essential part of FieldLog usage. The combination of the profiles and forms in FieldLog enforce a level of data collection, and furthermore a degree of terminology control, that guarantee that large databases are internally consistent. The structure shown for the SnowLake dataset is fairly typical of a geological survey's normal focus during mapping, but of course all users will want to customize FieldLog to some degree. Refer to Chapter 7 for details of customization.

CHAPTER 4

Querying a Database

Introduction

Although FieldLog would be useful if all it did was allow you to plot data to a map and build database files containing field data, FieldLog actually does much more — it leverages the power of relational databases and CAD programs to enable geologists to change the way geological map analysis is done. While serving as a cartographic tool, it also incorporates queries similar to those found in geographic information systems, and further adds a new class of queries based on a model of how geological nomenclature works.

Although most of the work you'll do in FieldLog is data entry and editing, the payoff comes when you mine the database for information. You can mine your database by:

- Querying the database for tabular reports
- Querying the database and plotting the results to the map
- Deriving stereonets of structural information via a query
- Plotting geochemical diagrams from database tables
- Exporting the existing database to advanced GIS software for further analysis

So far you've used fl-query to generate browsable scroll tables from the database. In this chapter you'll learn how to perform complex queries — displaying results on a map, generating diagrams, and exporting. You'll also explore the full power of FieldLog's hierarchical approach to geological data manipulation, the core of nomenclature based searches.

The fl-query command is a powerful aspect of FieldLog. It's extremely simple to use for basic searches, yet provides sophisticated power for advanced users. Many of the abilities of fl-query are not provided by even the most advanced GIS tools on the market because they were never intended for geological work — they are general purpose, whereas FieldLog is a specialized GIS tailored for geoscientists.

Before You Begin

If you aren't logged on to FieldLog and the *SnowLake* database, follow the steps from Chapter 2 to open *snowlake.dwg* and log on:

- Start AutoCAD, then open *SnowLake.dwg*.
- Load FieldLog using the menu.
- Logon to the *SnowLake* database using fl-logon from the AutoCad command line or the FieldLog menu.

At this point you should have a map of the SnowLake area displayed. Zoom out to view the entire map before you start the tutorial.

Benefits of Using Layers

What goes where?

FieldLog has a very complex set of choices to make when plotting to a map, such as what layer to plot on, what color to use, what symbols to use, and so on.

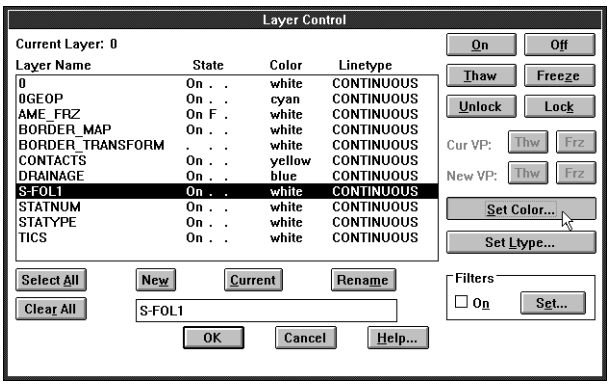
Plotting parameters for a particular item in FieldLog are stated in a Palette definition. Palette is available as a button item on many of the dialogue boxes. Palettes are covered in Chapter 7.

In Chapter 6, we'll discuss the importance of AutoCAD layers for separating different data types during map preparation. In this section, we briefly introduce you to using AutoCad layers in FieldLog. The following assumes you're familiar with basic AutoCAD functionality.

The foliations we added to the *SnowLake* database in Chapter 3 are on a layer named *S-FOL1*.

1. To open AutoCAD's layer control panel, type `ddlmodes` in the AutoCAD command line, or select the analogous icon from one of AutoCAD's toolbars.

   AutoCAD's Layer Control dialog box appears.



2. Select the *S-FOL1* layer, then click **Set Color**.

   The Select Color dialog box appears.

3. Choose red from the Standard Colors list, then click **OK**.
4. To exit the Layer Control dialog box and return to your map, click **OK**.

   Note that the foliation symbols and their dip measurements are now red. It's a good idea to set AutoCAD's colors up so that different data types have different colors. This allows you to keep track of what is going where, and where data is in cluttered areas of the map.

5. Zoom out to see the whole map.

Not only can layers be assigned a colour, but they can also be used to control the visibility of objects on the map. If map objects have been thematically grouped into layers then it is possible to make visible/invisible any combination of map layers. The ability to highlight or hide certain data allows you to easily build a variety of thematic maps from one basemap. Another way to do this is to physically remove data from the map but not from the database. Both methods have their place — layers are useful for thematic control, while removing data is useful for making a particular layer simpler to understand and less crowded when plotted.

Performing a Simple Query — Details

Thinking in Queries

First of all, remember that for a query to be useful, it must make geologic sense. Before running a query, think through what you are doing. In this case, we are going to isolate all of the first phase foliations observed in the SnowLake area by the workers who built the SnowLake FieldLog database. Thinking through the logic carefully can prevent major mistakes in the long run.

Prior to executing a query that will plot to the map, save the drawing. You can then revert to the saved drawing if the result is inappropriate or if an error occurs.

R13/14 Note

In R13/14, the first project is automatically selected in the *query database* dialog. In R12, you must manually select the project each time.

Now let's do a simple query — find all *S-FOL1's* in the *SnowLake* database and add them to your map. This time we'll go through the process in detail so you can see what each section of the query box is actually contributing to the process.

To start the query process:

1. Type `fl-query` in the AutoCAD command line or select it from the FieldLog menu.

   The 'Query database' dialog box appears.

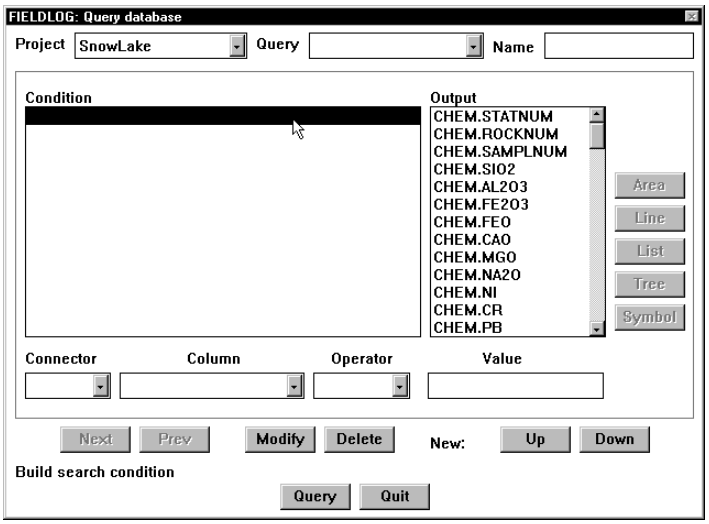


TABLE 1. Fl-Query Dialog Items

Project	If you have more than one database open, this allows you to choose which one to query. Normally you only have one database open, but in large or complex projects you may elect to spread the project between several sub-projects, each with its own name and database.
Query	Enables you to select from previously created searches, providing you named them. Most queries are used frequently, so get into the habit of using the *Name* box and giving queries common-sense names.
Name	The place you type in a name for the current query. The query is available the next time you return to fl-query.

Note

If you inadvertently click on a column that you don't intend to use, FieldLog includes it in the output list. Make sure you check your output list before issuing a query, as the selected columns affect the search results.

Query Nesting

FieldLog doesn't permit nesting of conditions. Conditions must follow one of the following patterns:

(1) (condition OR condition OR...) AND

(condition OR condition OR...) AND...

(2) (condition AND condition AND...) OR (condition AND condition AND...) OR...

Conditions using the special operations IS, HAS, INSIDE, OUTSIDE, NEAR must be connected with:

(condition AND condition AND...)

TABLE 1. FI-Query Dialog Items

Condition	The viewing area where query conditions that filter the database are built. You don't interact directly with this box except to select existing query conditions for editing.
Output	The area where you select which fields are displayed in the scroll table that results from running the query. Fields used in a query condition are automatically selected in this window.
Area	Allows a search of a geographic area on the map, selected using the mouse or digitizer. To use this feature you must select *Inside* or *Outside* in the Operator pop-up, indicating you want to search inside/outside a polygonal area.
Line	Allows a search based on proximity to a line on the map, usually known as a buffer search. To use this feature, you must select *Near* in the Operator pop-up. Enter the width of the buffer as a number in the Value field. The width must be in the current drawing units.
List	Allows you to specify a Value from a hierarchical profile associated with the column selected in Column. For example, structural data is tied to a structural profile, so you can choose the desired structure name to search on by selection from a list if the Column pop-up contains the field STRUC.FEATURE. You must, of course, select the Column before you use this button.
Tree	As with List, this button allows a search based on a profile, but in this case via a hierarchical browser.
Symbol	As with List, this button allows a search based on a profile, but in this case from a browser showing all the symbols associated with the profile.
Connector	Defines the logical relationship between entries in the Condition list. The two possible entries are: *AND* — When conditions are related by *AND*, both conditions must be true for the specific entry in the *Column* table to be returned into the Scroll Table view. *OR* — When conditions are related by *OR*, either condition must be true for the specific entry in the *Column* table to be returned into the Scroll Table view.
Column	This is the heart of the query table. The query built in the Connector-Column-Operator-Value boxes acts on the field in the database indicated by the Column entry. So, for example, to search for station numbers above a certain threshold, the column pop-up would be set to STATI.STATNUM. Much of the work involved in setting up a query involves deciding which column to run the query on.

Note

IS, HAS, INSIDE, and NEAR are non-SQL operators especially provided by FieldLog. They must be connected to any other condition using 'AND':

(condition AND condition...)

TABLE 1. Fl-Query Dialog Items

Operator	Contains all the acceptable logical operators that FieldLog can use. A search condition is satisfied if theValue of the specified Column in the database meets the search conditions:
	• > field must be greater than *Value*
	• < field must be less than *Value*
	• <= field must be less than or equal to *Value*
	• >= field must be greater than or equal to *Value*
	• = field must be equal to *Value*
	• **NOT=** field must be not equal to *Value*
	• **LIKE** allows searches based on **wild cards.** Valid wild-cards in SQL (the foundation of FieldLog) are:
	  • _ (the underscore character): This wild-card substitutes for any single character in the position indicated. For example, the search *STRUC.FEATURE LIKE SFOL_* would return all structural features SFOL1, SFOL2, and so on.
	  • % (the percent character): This wild-card substitutes for any number of characters in the position indicated. For example, the search *STRUC.FEATURE LIKE%1* would return all structural features ending with 1.
	• **NOT LIKE** is similar to *Like* except that it returns those entries that fail to match the criterion
	• **IS** acts on hierarchies in profiles within FieldLog. It returns elements that are of the indicated type as well as its subtypes. For example, the search *STRUC.FEATURE IS BEDDING* would return the *BEDDING, SUBED, S-BED* and *SOBED* features from the *SnowLake* database.
	• **HAS** is the logical complement to the *Is* operator. It returns elements that are of the indicated type or its super types. For example, the search *STRUC.FEATURE HAS BEDDING* would return the *BEDDING* and *PLANAR* features from the *SnowLake* database.
	• **INSIDE** — if you choose a location field in the Column pop-up (e.g. UTMX or UTMY in the SnowLake database), you can then search for stations inside a specified area. The Area button allows you to specify the target area by specifying the bounding polygon
	• **OUTSIDE** — as with INSIDE, but the query returns features that are outside the area specified using the AREA button
	• **NEAR** allows a buffer search — it finds all features within a specified distance of a line specified with the Line button. Specify the buffer distance in drawing units in the Value field.

Value	This field accepts logical, alphabetic, and numeric entries that must be satisfied by the search condition. For example, if you want to find all station numbers greater than 100, you put 100 in this field.
Next	Selects the Condition directly below the currently selected one. Use Next when editing existing conditions. Conditions can also be selected by clicking on them with the mouse.
Prev	Selects the Condition above the one that's currently selected.
Modify	Overwrites or enters the selected entry from the Connector-Column-Operator-Value fields into the Condition list. ***To modify an existing condition or insert a new condition, you must click this button.***
Delete	Deletes the selected entry in the Condition list.

Note

To create a new blank condition, you must click UP or DOWN. Then simply create the condition and click MODIFY.

TABLE 1. FI-Query Dialog Items

Up	Inserts an empty search condition into the Condition list, above the currently selected entry.
Down	Inserts an empty search condition into the Condition list, below the currently selected entry.
Query	Runs the query (if the query is valid).
Cancel	Closes the query box, cancelling the query.

2. Select *SnowLake* from the Project pop-up.

   The only choice in the Query pop-up is the *StatBrowse* query from Chapter 3. We'll make a new query here, so leave the pop-up blank.

3. In the *Name* box type `SfolSearch`.

   Remember that by naming a search, you can reuse it easily. Furthermore, if there's an error, you don't have to re-enter the entire query.

Choosing the Input for a Query

About Complex Queries

It is easy to get misleading results from any complex query, especially those that involve multiple conditions. When in doubt, work through the query slowly and make sure the query does what you want! Most people run into problems when using the AND connector. For example the following condition is impossible:

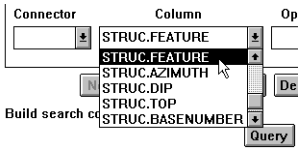
Feature=s-fol1 AND Feature=s-fol2

The Feature column can contain only one value, s-fol1 or s-fol2, but not both! In this case OR is required to indicate that both s-fol1 and s-fol2 occurrences are to be returned from the query.

The = and IS operators are also often misused. Use the = operator when you want the condition to return a single value (e.g. = s-fol1 -- all s-fol1 measurements). Use the IS condition when you want the condition to return a family of values (e.g. IS Planar -- all planar measurements).

First you choose the table you want to query and then you select the columns that you want included in the query. Remember that the tables are organized to roughly mimic the organization of fieldwork — traverses, stations, and structure, lithological, sample, and photo observations. Here we want to look for structural information.

1. Select *STRUC.FEATURE* from the Column pop-up.



   The current line in the Condition box queries the feature name in the Structure table. Since this is the field that names the individual structural entities, this is where you search to eliminate structures that don't meet chosen criterion.

2. Select = from the Operator pop-up.
3. Click inside the Value edit box, then click **Tree**.

   The Tree Selection dialog box appears. Tree selection is based on a hierarchical organization of nomenclature.

4. Select *s-fol1* from the *PLANAR>FOLIATION* section of the tree.

   S-fol1 appears inside the Value edit box. (If you know the name of the value you want to query, you can type its name directly into the Value edit box.)

   The query we've entered, *STRUC.FEATURE = s-fol1*, finds any entries in the structure table that are *s-fol1's*.

5. To insert the condition into the Condition table, click **Modify**.

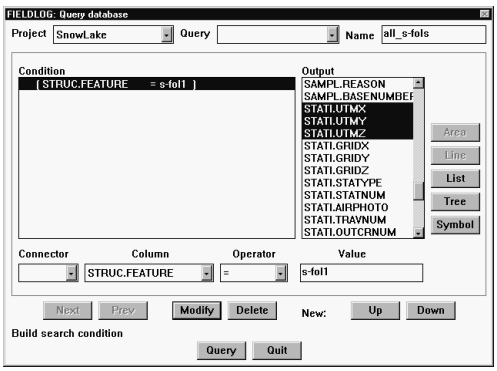
There should now be an item in the main body of the dialog. If a row in the main body is highlighted, you can edit it by changing the characteristics in the pop-ups and then clicking **Modify** once again.

Choosing the Output for a Query

Now that you've set up your condition and entered it into the Condition list, you must choose the type of output you want. Let's output the results onto *snowlake.dwg*. In other words, we'll direct the features that meet the query condition — all *s-fol1's* — to be plotted to the map. To output the symbols on the map, FieldLog needs to know:

- *STRUC.FEATURE* — the feature to be drawn
- *STRUC.AZIMUTH* — the strike direction of the symbol
- *STRUC.DIP* — the dip value for the symbol
- *STATI.UTMX* — the X location
- *STATI.UTMY* — the Y location

1. In the Output list, select *STRUC.FEATURE*, *STRUC.AZIMUTH*, *STRUC.DIP*, *STATI.UTMX*, and *STATI.UTMY*.



R13/14 Note

In AutoCAD R13 and R14, the Scroll Table dialog box has an additional output item, called *Image or Sketch*. This allows you to review all raster images that were returned by the query (for example, you can use it to review field photographs).

The images are shown sequentially in the AutoCAD window. For each picture, you can show it or not, in effect acting as a pause between images. After the last image is displayed, press **Enter** to finish. Press **Esc** to stop image viewing.

In AutoCAD R13 and R14, two radio buttons appear with Plot Options that allow you to specify whether you want all query items plotted, or only the rows you select. The *Clear* button unselects all currently selected rows.

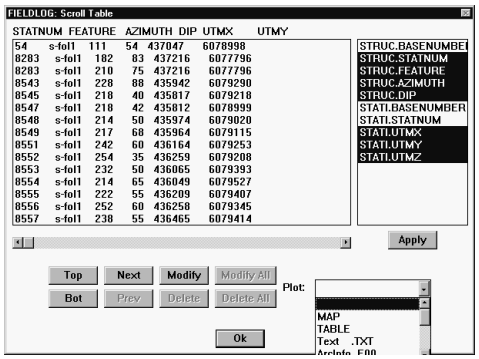
Running the Query

Now that you've created conditions and output options, you're ready to run the query. FieldLog takes the query you create, translates it into an SQL statement, and passes it to the AutoCAD database engine which attempts to execute it.

1. Click **Query**.

   A message box appears indicating that FieldLog found records that matched your query. Depending on how large your database is, you may have to wait a few seconds.

2. Click **OK** in the FieldLog message box.
3. The Scroll Table dialog box appears, displaying a list of values that match your query. If you move to the bottom of the list you should see the two measurements — *me1* and *me2* — that you entered into the database.

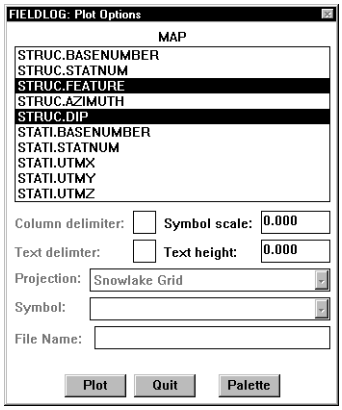


4. To plot the symbols, select *MAP* from the Plot pop-up.

   Remember that AutoCAD is acting as a drafting engine, and FieldLog is acting as a notes storage and query engine. If you plot to a map, FieldLog tells AutoCAD to draw new symbols to the map. Unlike the results in many desktop GIS programs, these entities are permanent, and have to be erased manually to clear them.

   The Plot Options dialog box appears, asking which items to plot. Depending on what you're plotting, you may be able to specify parameters.

5. Select *STRUC.FEATURE* and *STRUC.DIP*, then click **Plot**.



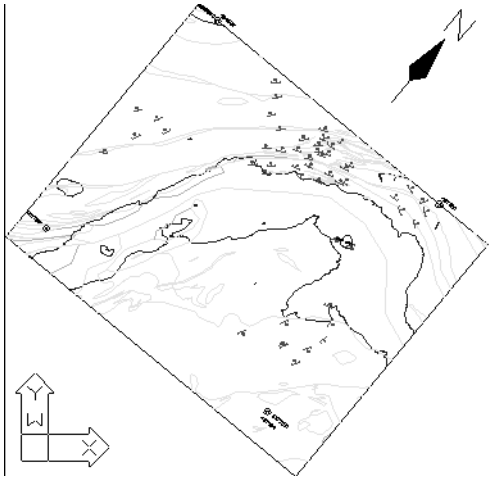
   This is equivalent to plotting just the structural symbols with adjacent dips. FieldLog's palette setup for the *Struc.feature* column knows which symbol to use and knows to access *Struc.azimuth* to get rotation information. The Palette is accessible from the Plot dialog box. Also note that plotting the azimuth itself results in rotation amount being plotted to the map as text.

   FieldLog plots the output. When it's finished, FieldLog displays a message with the number of records plotted and warns of any values it couldn't plot.

6. To exit the scroll table, click **OK**.

Your map should now contain a large number of foliation measurements (they'll show up in red if the layer *s-fol1* is set to red, as done earlier in this exercise).

With a plotter hooked up, you could print a quick plot of first phase foliations — a custom map in less than 10 minutes! And if you named the query, it takes less than a minute to reuse the query.



We've covered a lot in this section. The possible Operator choices in FieldLog are a bit intimidating at first, but remember that these options are the key to FieldLog's power and flexibility. Take some time to try each one out.

Now let's try another query, retrieving geological features from an area on the map using the Inside operator.

Performing a Spatial Query

Navigation in AutoCAD

To move around an AutoCAD drawing, use the following commands:

- **zoom** to zoom in or out — the **W** option in zoom allows you to pick a window to zoom in to
- **pan** to move around on the view by shifting the current view in small increments

See Chapter 6, AutoCAD review, for more information on these and other AutoCAD commands.

Now that you know how to perform a simple query, you're ready to perform a more sophisticated query — a spatial query on a selected area of your drawing.

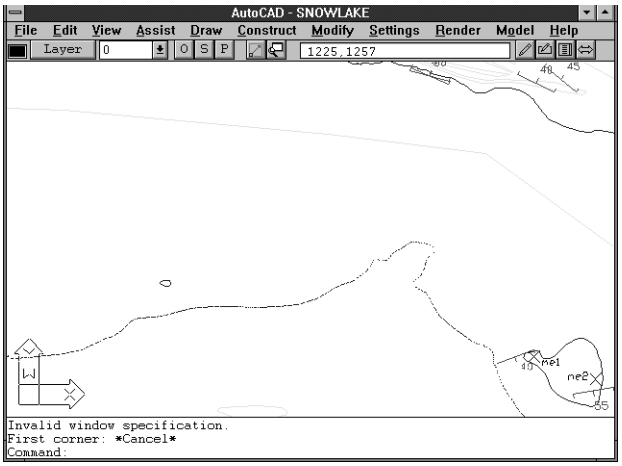
Spatial queries are key features of GIS software — any database can do queries such as finding all *s-fol1's*. But few databases can find all *s-fol's* within a highly irregular area. The advantages of FieldLog are the geological nature of the database (including the fact that you can build hierarchical lists of terms) and the ability to do spatial searches just as an advanced GIS package would. In fact, because you can express your spatial queries using hierarchical relationships, FieldLog surpasses most GIS packages in terms of expressing complex geological queries.

Before you begin the query, use AutoCAD's zoom command to set your view so that the island containing stations *me1* and *me2* is on the right extremity of the screen and fills about 5% of the screen width.

Selecting a Query Area on a Map

In this query, you'll pick an area on your drawing and ask FieldLog to list all of the existing structural measurements for that area. Make sure you've zoomed to approximately the area shown in the following figure.

1. Type `fl-query` in the AutoCAD command line or select it from the FieldLog menu.
2. In the Query dialog box, select *SnowLake* from the Project pop-up.
3. In the *Name* field, type `StrucArea`



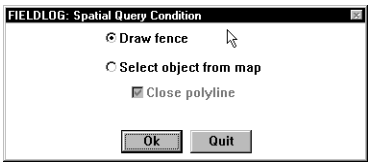
Using Objects to Select Areas

If you use an existing object to define an area, FieldLog allows you to close the object to complete the polygon automatically. The object must, however, be a continuous, uninterrupted polyline.

If *Close Polyline* is toggled off, then FieldLog doesn't accept open polylines to indicate areas.

4. To choose an area, select *STATI.UTMX* from the Column pop-up. The Area operator in FieldLog must operate on a field that contains location information of some sort.
5. Select *Inside* from the Operator pop-up.
6. Click **Area**.

   FieldLog replaces the Query dialog box.
7. The Spatial Condition dialog appears. Leave it set to *Draw fence.*



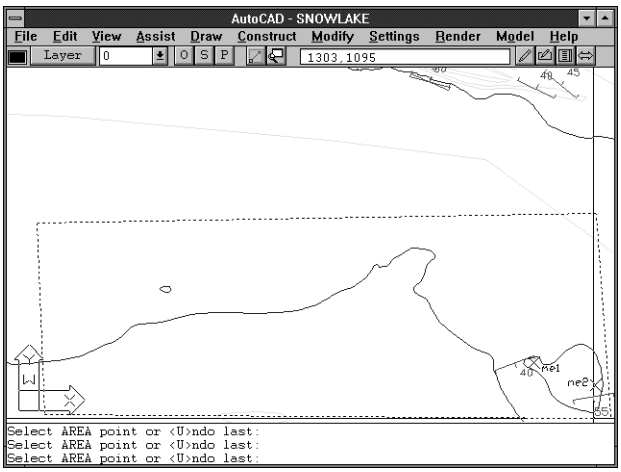
The *Select Object From Map* option allows you to use an existing item on the map, such as a geological unit boundary, as a search area.

Click three or more points to define a polygon-bounding fence enclosing your area of interest. Make sure you choose a fairly large area so that your query finds some stations. Don't close the polygon.

Note

FieldLog doesn't permit edges of the polygon to overlap. This message appears if this occurs:

Picking a point outside the AutoCAD window may also cause this message to appear. To remedy this, cancel the polygon with *ESC* (R13/14) or *Ctrl-C* (R12) and start over.


AutoCAD - SNOWLAKE
File Edit View Assist Draw Construct Modify Settings Render Model Help
Layer
1303,1095
Select AREA point or <U>ndo last:
Select AREA point or <U>ndo last:
Select AREA point or <U>ndo last:

8. To finish, press **Enter**.

   This closes the polygon and returns you to the Query panel.

   The Value box should say *AREA*. This indicates that FieldLog has stored a list of points from the map to define the area. If it hasn't, try again.

9. To add the query to the Condition table, click **Modify**.

   The query should now appear in the list box.

Selecting Data

1. Select the following in the Output list:

   STATI.UTMX

   STATI.UTMY

   STATI.STATYPE

   STATI.STATNUM

   STRUC.FEATURE

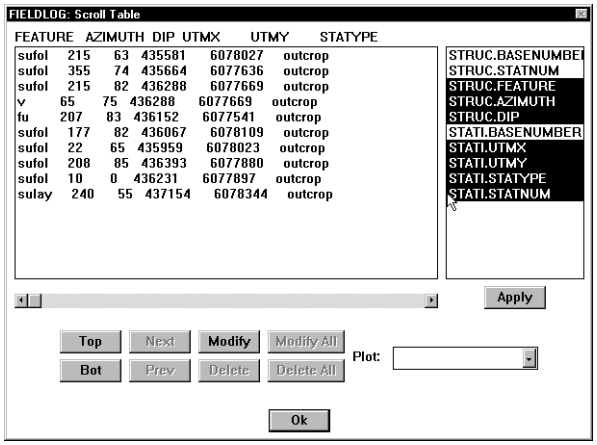
   STRUC.AZIMUTH

   STRUC.DIP

   Note that as usual, we select the *STATI.UTMX* and *STATI.UTMY* columns so that our output options include required location information.

2. Click **Query** and then **OK** when the message box appears.

   The Scroll Table dialog box appears, listing the data.



   Your specific display may differ from the one shown above, because it's likely you'll have chosen a different area of the map. If no data appears, you chose an area with no measurements. Return to fl-query and rerun *StrucArea* on a larger section of the SnowLake map. Remember to click **Modify** to update the condition after you have selected a new area.

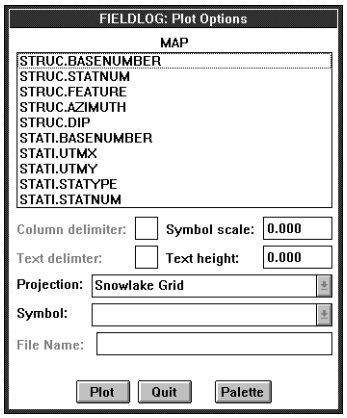
Plotting Data

Next, you'll add all measurements found by the query to the map view. Remember that FieldLog maintains the geological database independent of

the map, so that you'll routinely add and remove symbols from the map as you do cartographic work and analysis.

1. To plot the data, select *MAP* from the Plot pop-up.

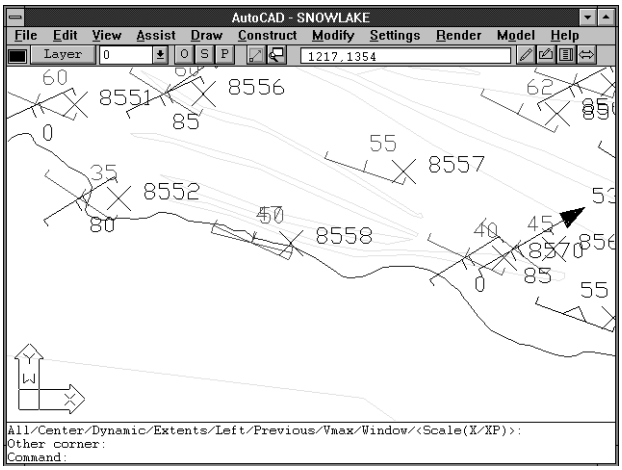
   The Plot Options dialog box appears.



   Notice that, depending on the type of plot option, Plot Options allows you to override some of the projection, palette, delimiter, and size parameters. When plotting to a map, only the size parameters are available. *Symbol scale* denotes a scale factor to be applied to symbols, whereas *Text height* refers to an absolute size, in drawing units, for plotting the text.

2. Select *STRUC.FEATURE, STRUC.DIP, STATI.STATNUM,* and *STATI.STATTYPE,* then click **Plot**.

3. Zoom in on the new data.



   Note that FieldLog has placed a variety of different data types on the map — station numbers, structural symbols, and dip values. If you examine the layer definitions within AutoCAD you'll see that the symbols are layered by data type. The layering is defined using fl-setup, the FieldLog configuration menu item, but can be overridden within the Plot Options dialog box using the Palette button, as discussed earlier.

Performing a Compound Query

About Connectors

And and *or* are examples of condition connectors. These can be a bit confusing.

- *And* returns only records that satisfy both listed conditions perfectly.
- *Or* returns records that satisfy either condition.

Remember that a field in the database with only a single value per field can't have different values, and so the *and* operator always returns an empty set if you do a compound *and* query on it. Think about this.... X = a AND X = b is impossible!

Finally, let's do a compound query. A compound query finds data that meets the conditions contained in two or more separate condition rules. Here is our query, in geological terms:

Query in geological terms	Translated to FieldLog query
Find all pillow basalt samples that have a planar structural measurement occurring at the same station.	Condition 1: *LITHO.ROCKTYPE = Pillow Basalt* Join: *and* Condition 2: STRUC.FEATURE IS Planar

Before you begin, use AutoCAD's zoom command to zoom to the extents of your map. If FieldLog is not loaded and/or you are not logged on to the *SnowLake* database, do so now.

Beginning the Query

1. Type `fl-query` in the AutoCAD command line.
2. In the Query database dialog box, select *SnowLake* from the Project pop-up.
3. Name the query `PBStruc`

Setting Up Conditions

To set up a condition requiring all selected stations contain Pillow Basalts:

1. Select *LITHO.ROCKTYPE* from the Column pop-up.
2. Select = from the Operator pop-up.
3. Click **List**, then choose *Pillow Basalt.*

   Pillow Basalt should now be displayed in the Value edit box. This selects all stations where a pillow basalt was observed.

4. To add this to the Condition list, click **Modify**.
5. To insert the next condition below this one, click **Down**.

   You must establish a relationship between the second rule and the first. To get results that meet both rules:

6. Select *AND* from the Connector pop-up.
7. To choose only planar structures, select *STRUC.FEATURE* from the Column pop-up.
8. Select *IS* from the Operator pop-up.
9. To get a list of available structures, click **Tree**.
10. Select *Planar*, then click **OK**.
11. Click **Modify**.
12. Select the following output values:

    LITHO.ROCKNUM

    LITHO.ROCKTYPE

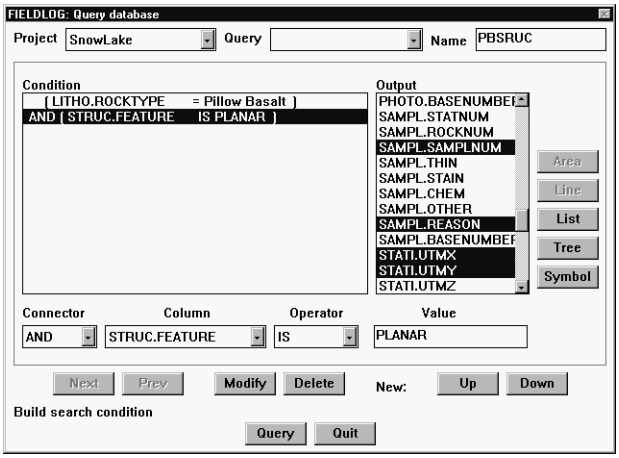
SAMPL.SAMPLNUM

SAMPL.REASON

STATI.UTMX

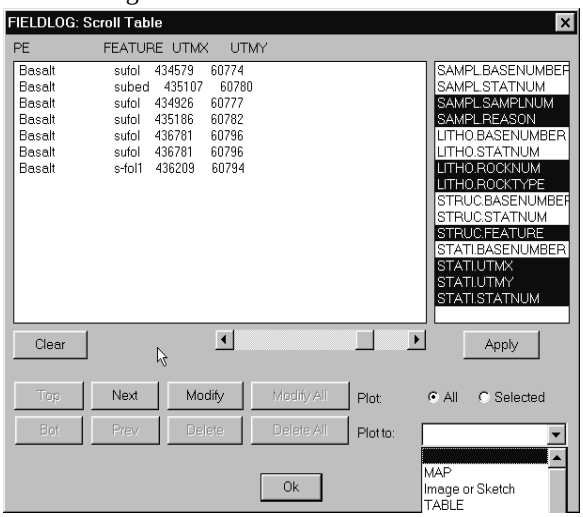
STATI.UTMY

STATI.STATNUM



13. To submit your query, click **Query**.

    The resulting scroll table should look similar to the one shown below.



Exporting Query Results

Before exiting the query, you can also export the results to a text file. This is useful for preparing a report, exporting data into another program, or archiving subsets of a database.

To export query results to a text file:

1. Select *Text.txt* from the Plot pop-up.

Other Plot Output Options

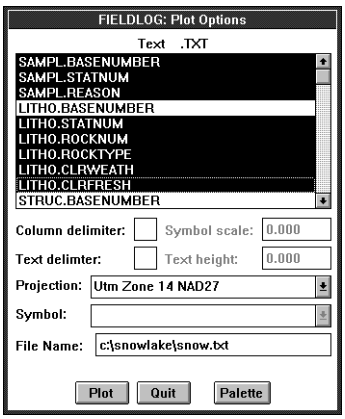
You've learned how to plot the results of a query to a text file. Other options include:

- Arc/Info E00 — E00 files are the standard interchange file for ArcView, ArcView2, Arc/Info, and ArcCAD. If you need Geological Survey regional data, chances are it's available in E00 format.
- Map/Info MIF — Map Info is a desktop and laptop GIS common in the mining and business community.
- Spans — Spans is a raster GIS well suited to raster analysis and geoscience modelling.
- Stereonet — FieldLog generates equal area and equal angle point stereonets and plots them to the current map view.
- Rose Diagrams — FieldLog generates rose diagrams and plots them to the current map view.
- Geochemistry — FieldLog generates x-y plots and x-y-z plots given a user-specified formula relating FieldLog database fields to an x-y or x-y-z grid. These are plotted to the map.

2. For output, select all items except for those ending in *BASENUMBER*. These are internal FieldLog record numbers and generally aren't useful outside of the program.
3. Select *UTM ZONE 14 NAD27* from the Projection pop-up.

   FieldLog allows you to re-project the station locations. This can be crucial when:

   - Exporting data into other programs
   - Matching specific data format requirements
   - Standardizing data archives
4. Type `c:\snowlake\snow.txt` in the File Name edit box (assuming you've put your sample data in the `c:\snowlake\` directory.



5. To output the data to the text file, click **Plot**.

   A message box appears, indicating that the records are plotted.
6. Using a text editor or word processor, open up the text file you just created (in this case `c:\snowlake\snow.txt`).

   The text file should contain the same information as the scroll table.

That's it! You've done simple, spatial, and compound queries — outputting the results to a table, a map, and a text file. The fl-query command is powerful yet relatively simple. As you get more familiar with FieldLog you'll begin to naturally think in terms of how to express queries.

Conclusions

In this chapter you learned how to:

- Manipulate the colors of entities by AutoCAD layer
- Perform a simple query
- Perform a spatial query.
- Perform a compound query
- Export data to a text file
- Plot database data to the map view

The FieldLog Query dialog box can be intimidating, and the options available from the data browser are quite diverse. However, the geological questions that can be addressed using the combination of operators in the Query dialog box allow you to address real world problems with your data. And the data mobility and thematic map flexibility of the data browser allow you to migrate your field notes into stereonets, thematic diagrams, and to other systems.

A few of the operators found in the Query dialog box may seem fairly strange at first, but turn out to be the most useful when it comes to dealing with real, often ambiguous geological data. At an organizational level, the divergence in naming between different mappers has for years been a severe limitation on doing queries in a GIS environment. The hierarchy operators in FieldLog, based on artificial intelligence techniques, directly reflect the core of the mapping problem — where are rocks *similar,* rather than only *named identically.*

CHAPTER 5

Attaching Data to Lines

Introduction

All of the data you've worked with so far in this tutorial is associated with points on a map. Structural geology measurements, samples, and photos are all keyed to a station location, just as they would be when you recorded them in your notes. Associating database entries with point entities on the map is the normal mode for FieldLog data, though not the only possible one.

While most field measurements are well suited to being treated as points, there are cases where it's useful to label other entities — usually linework — with FieldLog database records. This labeling would allow a direct association between features such as faults and contacts and the FieldLog database. The data could then be accessed by clicking on the drawing using Fl-edit.

In fact, in a full GIS for an area, there would likely be point data such as station-based observations, line data such as contacts and lake shores, and polygonal data such as geological unit extents. FieldLog directly supports the generation of line and point datasets, concentrating of course on the point data. AutoCAD, especially versions before R14, is extremely limited in handling polygonal data. However, as discussed in the sidebar, it's possible to label polygons in FieldLog.

In this chapter, the final chapter of the tutorial, you'll learn how to associate FieldLog data with linework.

Polygons in FieldLog

FieldLog does permit polygons to be attributed. Data can attached to the polygon's bounding line, or a text label can be positioned inside the polygon and linked to a database table that contains the polygon attributes. The text label is positioned using the standard fl-add functionary. It's very useful to label polygons in this second way, and to record associated descriptive information, including the label location, in a database table because most GIS systems require the label and its location before they recognize the polygon. See the *UNITS* table in the SnowLake database for an example.

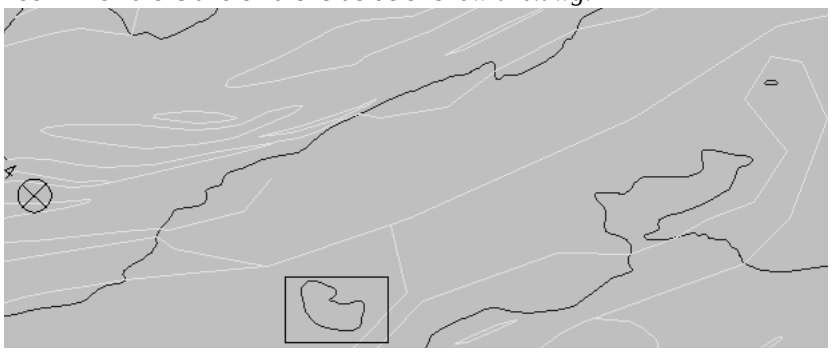
Or, if the polygons are created using a single enclosing line, the data can be attached to the line, as described in this chapter. In this case, the polygon label should be a text column located in the row to which the line is being attached.

Line Attachments

If you aren't logged on to FieldLog and the *SnowLake* database, follow the steps from Chapter 2 to open *snowlake.dwg* and log on.

Adding an Outcrop to Your Drawing

1. Zoom in on the island on the left side of *snowlake.dwg*.



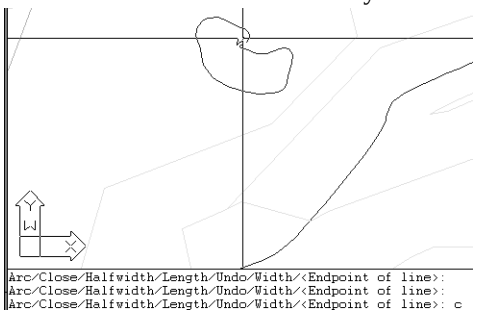
   Once you've zoomed in, the island should fill the center half of your screen

2. Use the **layer** or **ddlmodes** command to make a new layer named *outcrop* and make it the current layer.

   Its name should appear in the layer display in the upper left part of the AutoCAD window. All new drawing entities are placed on this layer. While FieldLog automatically places new AutoCAD entities on proper layers as it creates them, you have to do this manually for linework you add using AutoCAD commands such as **pline** — AutoCAD's default layer is always the active layer.

3. Use AutoCAD's **pline** command to sketch a quick outcrop on the island near the bay. Use pline's **close** option to finish the outcrop's outline with a perfect closure.

   If you're unfamiliar with pline and other drawing commands, read Chapter 6 for a brief introduction or refer to your AutoCAD manual.



   Close the pline properly. If you're going to migrate data to a desktop or workstation GIS environment, you must properly close the linework that defines polygonal areas. See Chapter 6 for notes on digitizing.

Associating Data with the Outcrop

Creating a New Entry

First, create a new Traverse entry for your whirlwind island visit.

1. Type `fl-add` in the AutoCAD command line.
2. Select *SnowLake* from the Project pop-up.

3. Select *TRAV* from the Table pop-up.
4. Enter the following values:

TRAVNUM	`30`
GEOLOGIST	`me`
NTSMAP	`63k16`
FIELDDATE	`19960405`
SUMMARY	`Detail on Island Outcrop`

5. To add the traverse to the database, click **OK**.

Adding an Outcrop Description

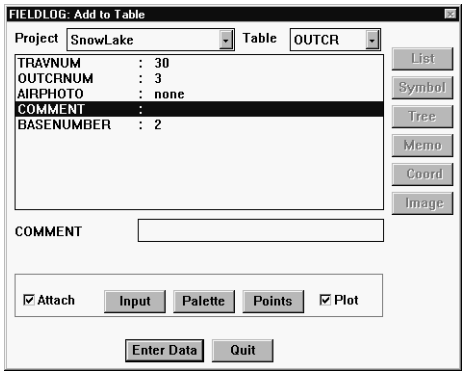
Outcrops are, conceptually (to FieldLog), areas of geological interest that may contain more than one station. Since you drew an outcrop outline it's only natural that you now associate an outcrop table entry with that linework. There will then be a logical link between the two, and this link is passed on if you export the data to another GIS program.

To add an outcrop description:

1. Type `fl-add` in the AutoCAD command line, or pick it from the menu.
2. Select *OUTCR* from the Table pop-up.
3. Enter the following values:

TRAVNUM	`30`
OUTCRNUM	`3`
AIRPHOTO	`none`
BASENUMBER	(use provided value)

4. Make sure that the *Attach* checkbox is selected (you want to link the outcrop table entry to the outcrop's outline).



5. Click **OK**.
6. Select the outcrop's outline, then click to attach.

7. When prompted for more links, click **No**.

Linking Logic

When linking database information to entities on the map, there are a few things to keep in mind:

- You're trying to build links where the items are conceptually linked. Use links sparingly to avoid chaos.
- Be aware of the size of the entity you're linking to. If it's a pline, it may very well extend onto other areas of the map, where the observations linked would be out of context.

A single record can be linked to multiple AutoCAD entities, but a single AutoCAD entity can only be linked to one record. Adding later links will sever earlier ones.

Overwriting Links

FieldLog maintains only one database link for any AutoCAD entity it creates. If you link an AutoCAD entity to a row in the database, and later link the entity to another row, the first link is overwritten (destroyed). However, the contents of the database are unaffected.

Verifying that an Attachment Worked

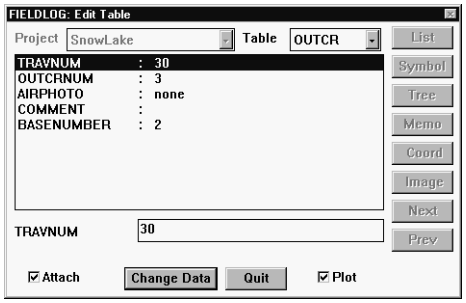
The point of attachments is that you can access tabular data by clicking on a drawing entity — the entity and the table become conceptually linked and this link persists if the data is exported.

You can check whether an attachment worked by clicking a drawing entity that should contain attachments.

Now verify that the outcrop is attached to the database.

1. Type `fl-edit`, then click the outcrop's outline.

   If you attached the station to the outcrop correctly, the Edit Table dialog box for outcrop 3 appears.



Conclusions

In this chapter you learned how to:

- Attach data to screen entities
- Verify that the attachment took place

Summary

This tutorial introduced the main concepts you need to use FieldLog. Now you're ready to work as a FieldLog user. If you want to learn more about FieldLog and AutoCAD, here's what you'll find later in this manual:

- Chapter 6 provides details on AutoCAD.
- Chapter 7 covers setup and customization procedures.
- Chapter 8 covers import/export procedures and using external databases. It also has instructions for mobile computing using an Apple Newton, including on site data entry and data transfer to FieldLog.
- Appendix A includes installing FieldLog software and databases, project setup, software upgrades, and custom symbol libraries.
- Appendix B contains a description of FieldLog, data models, relational databases, and FieldLog's database design.
- An annotated bibliography of GIS for Geologists, which lists websites, papers, and book references.

CHAPTER 6

Map Preparation with AutoCAD

Introduction

AutoCAD is a powerful computer aided drafting (CAD) program. It enables you to draw and display maps. FieldLog builds on this infrastructure to construct a field data system. Unfortunately, AutoCAD also contains many functions that are of little or no use for geological map production, data archiving, and query-based data access, so that navigating the regular AutoCAD documentation can be frustrating and intimidating. This chapter provides a quick overview of AutoCAD and briefly describes the AutoCAD commands you must know to use FieldLog effectively.

FieldLog v3 was developed to support AutoCAD versions R12-14 which is reflected in differences between the AutoCAD interfaces. This chapter assumes that you are running AutoCAD R12 for Windows. Command-line data entry hasn't changed significantly between the supported versions, so we assume that you're typing commands rather than using menus.

At this time there are no plans for the further development of FieldLog to support newer versions of AutoCAD, such as AutoCAD 2000.

Drawing a Map

As discussed in Chapter 1, FieldLog is a specialized but rudimentary GIS that primarily stores point data. This means that while it's well suited to storing, querying, and outputting field data from defined positions, it doesn't allow the construction of a proper geological map, since geological maps typically:

- Show contact types
- Have shaded, coloured, or symbolic patterns to indicate lithology
- Make extensive use of secondary text and drawing for legends and location insets — also known as cartographic annotation

To overcome these shortcomings various AutoCAD functions must be invoked.

When you need to produce a map using FieldLog and AutoCAD, FieldLog uses the data you enter to provide the geological constraints for linework showing contact and other geological relations. Some lines may have FieldLog data attached, however, most of the linework starts and ends as AutoCAD, not FieldLog, entities.

Typically map production is aided by reference to historical maps. A new map is plotted onto a base that is either digitized from an existing paper map or onto an existing digital map that represents the topographic and cultural features of the map area. If you are digitizing the base yourself, chances are that you'll be doing this in AutoCAD, using the commands reviewed below. If you purchase a base map from a governmental or third-party source, you can normally purchase it in DXF, the AutoCAD transfer format. Regardless, you need to know a minimum amount about AutoCAD to be effective with FieldLog. This chapter provides the core of that required knowledge.

AutoCAD is a relatively straightforward program. But, like any program, it's useful to have both a conceptual background — how it works, and a procedural background — how to get it to perform. We'll start with a conceptual background.

What is AutoCAD?

About Themes

If you use other GIS software, especially Arc/Info, you'll often see the word theme, but rarely the word layer. This reflects the conceptual foundations of each type of software — CAD software doesn't focus on what data is, just on drawing it. GIS software, on the other hand, is totally concerned with what the data is and often doesn't even have a permanently visible display area.

You should get in the habit of thinking of each AutoCAD layer as a distinct conceptual theme, as this leads to a more flexible layer structure in the long term.

AutoCAD is a **C**omputer **A**ided **D**rawing or Design (CAD) program. AutoCAD is a very sophisticated set of tools for putting graphic entities such as linework and text into a file that can then be viewed and printed. Like FieldLog, AutoCAD has at its core a database. The difference is that AutoCAD's database is oriented around rapid drawing, not geological research. While AutoCAD can quite efficiently represent a line or a point in two or three dimensions, it doesn't try to track what that linework means to the user. Think of AutoCAD as a highly paid draftsperson who carries out your instructions for making a drawing — it doesn't really care about the topic of the drawing, but it draws very well nonetheless.

From a geological point of view, the structure of AutoCAD is based around storing linework, text, and symbols, and then layering these entities for the convenience of the user. AutoCAD has a large number of tools for:

- Controlling the view of the drawing you can see
- Adding and removing map entities
- Layering data

Grouping Data

As different *thematic* data accumulates in one drawing, confusion can result due to clutter, interference between map entities, and the difficulty of tracking original source characteristics for diverse data. Ideally each *theme*, or related bunch of drawing entities, should be stored independently, so that they can be viewed individually or in any combination. We want, for example, to be able to view all of the roads in a map area, but sometimes we'd like to hide them so that they don't obscure geological relationships. We also want to be able to control colours and linework styles (dots, dashes, and so on) by theme, so that modifying

a drawing to be printed on monochrome or colour printers and at different scales is painless.

AutoCAD achieves this type of control when you assign similar data to *layers*. Each layer can be shown or hidden, have colour globally changed, and have linework properties changed without affecting other drawing layers. Combining select layers can deliver *thematic maps* that neatly sidestep the clutter problem. In addition, secondary information such as legends and annotation can be stored on separate layers and displayed only when plotting final output. This speeds display times and further reduces clutter during routine data entry and manipulation.

If you take the time before you start a project to set up layers that are well suited to your needs, you will be rewarded by flexibility and elegant control throughout the use of the drawing. Whenever possible, separate data according to theme and different source onto individual layers — it's trivial to combine layers later on, but laborious to split a layer once the drawing is under way. Keep careful track of what sources were used and what limitations or assumptions are associated with the data. This can save you endless trouble later on. In GIS this 'data about the data' is called *metadata*. It's your vital quality control information.

What This Means

Layer Notation

FieldLog, when plotting data to the map, automatically assigns the data to an AutoCAD layer. You must therefore ensure that data sets that you have digitized or imported, and that may not be in the FieldLog project database, have their own unique layer names. For example, digitized data placed on an AutoCAD layer called *SIUBED* is inseparable from *SIUBED* bedding data plotted to the map by a FieldLog query. Digitized or imported data that you wish to keep separate from your database should be placed on a distinct layer such as '*SIUBED_digitized*'.

AutoCAD was originally designed to draw architectural and machine-shop designs. In order to use AutoCAD to make maps we need to learn the areas where AutoCAD doesn't handle real world map making problems very well, and also to recognize and take advantage of its strengths.

Potential problems include:

- Accuracy of linework and closure of polygons
- Curvature of the earth (introducing distortion in maps of large areas)
- Problems with scale

To address these issues, you need to know something about how a GIS works so that you can see how to solve these problems in AutoCAD.

Data Types in GIS

Given that we want to have some GIS capabilities within AutoCAD and might eventually want to export FieldLog data to a full GIS, it makes sense to consider how a GIS stores data and how that affects our use of AutoCAD.

GIS software uses two general data models, the Raster andVector Models.

- The Raster Model models the world as a regular array of cells much like the surface of a television set. Attributes are associated with individual cells, and the array covers the area of interest. This model is well suited to geophysical datasets such as gravity and magnetics, to remotely sensed data, and to geological data when flexible modelling is paramount (Bonham-Carter, 1994). However, it's poorly suited to map production because the cell size places fundamental limits on the quality of output data and because entities such as roads that are contiguous in the real world are modelled as discrete, disconnected cells.

Projection Systems

Projection systems are mathematical ways to transform geographical coordinates (on a sphere) onto flat coordinates.

- The Vector Model, on the other hand, breaks objects down into points, lines, polygons, and possibly other entities such as faces, surfaces, or volumes — associating attributes with any or all of these. FieldLog is a limited GIS in that it handles points well, has limited capacity to attach attributes to lines, does very little with polygons or other geometric data types, and uses AutoCAD for drawing vectors rapidly. A robust GIS would contain a database of points, lines, polygons, and possibly other geometric data types, and it would permit information to be associated with any of these. It could then also draw a map based on a particular subset of its database. From this perspective, FieldLog stores a database of points, some tags on lines, and associates these with an AutoCAD drawing. AutoCAD internally maintains a database of drawn entities and separates these onto layers.

Data types in geology (and basemaps)

Data type	Sample geologic features
raster	geophysical data, continuous field data such as hydro, geochemical, and geophysical field data
point	field stations, structural measurements, sample locations, photograph centers, and so on (height of land, monuments, benchmarks)
line	faults, contacts (roads, rivers, pipelines, powerlines, and so on)
polygon	geologic units, equal-value polygons for geochemical data (lakes, islands, town outlines, and so on)

The Curvature Problem

Datum

Besides selecting the proper projection for your area, you must also specify the datum used. For example:

- North American Datum 1927
- North American Datum 1983

The datum is a measurement of the Earth's ellipsoid used in calculating a projection. The same point on the earth's surface differs by as much as 200 metres, in the UTM projection, if the correct datum isn't used. Projection information is usually listed in the border section of a map.

When a GIS draws a map from its database, it takes careful account of the geographic factors like shape of the earth and desired map projection. AutoCAD, however, is a drafting program and it considers the world flat. FieldLog keeps track of a map's projection system (typically Universal Transverse Mercator in Canada) so that it can back calculate what the geographical coordinates are and take the earth's curvature into account. In effect, when you digitize or add data points to a FieldLog database, you need to explicitly specify to FieldLog the projection system of the current data. FieldLog can then correctly store the data in AutoCAD so that keeps track of curvature and other projection problems. FieldLog is flexible in this because, in addition to standard systems and projections such as UTM, Lambert, and Geographic Coordinates (lat.-long.), FieldLog allows you to define a user defined grid projection system.

It's extremely important that when you digitize a piece of a map you tell FieldLog the correct projection system and datum, otherwise FieldLog and AutoCAD can't handle the data correctly!

Closure

The fundamental requirements of a vector GIS are that:

- Points are accurately positioned
- Polygons close exactly

Accurate positioning includes not only proper placement on the curved surface of the earth, but also correct absolute placement — if you digitize a map sloppily, you end up with a sloppy database.

Not only must the drawing entities be accurately placed, but it's important that they close.This means that you must ensure that any polygon you use to represent a geological unit is completely and perfectly closed in by linework. Linework that appears closed at one scale may in fact be open. You can check this by zooming in. Truly closed linework remains closed despite unlimited zooms on any given vertex. AutoCAD has tools to ensure a polygonal area is closed when you digitize it. We'll discuss these later in this chapter.

Scale

About Basemaps

If you're about to embark on a major field project using FieldLog, you're facing not only the task of FieldLog setup, but also the task of basemap preparation.

To properly digitize a typographic basemap is a daunting task.

You may want to consider purchasing digital basemaps from the federal, provincial, or state government or a third party source.

In Canada, 1:20,000 scale basemaps are available for some areas of provinces from the provincial government. 1:250,000 scale basemaps are available from the federal government. All are available as DXF files, which FieldLog can easily load and, if necessary, re-project to suit your specific needs.

Finally, any map has a nominal scale. If we digitize a basemap at 1:25000 for use in a 1:250 000 soil survey, the basemap will be unnecessarily detailed, meaning wasted hours of digitizing, and will often be cluttered as well. If we digitize a basemap at 1:25000 for use in a 1:5000 detailed mapping project the basemap will likely be too crude to use. This means that you should carefully choose sources at an appropriate scale and choose appropriate data *types* when you make a map. At 1:25000 an outcrop might be a small polygon. At 1:250 000 it's a point. At 1:5000 it might actually contain several smaller polygonal areas. Choosing the right *representation* for features is often just as important as accurately digitizing them in the first place. One useful trick is to make a sketch map at the final scale of your project (say, the scale of a map you have to deliver in the near future). Do points best represent outcrops at this scale? What scale basemap do you need? A little intuition and thought goes a long way here, and saves you a lot of time in the end.

AutoCAD Commands

The remaining part of this chapter details key AutoCAD commands and provides some insight on how they are used with FieldLog. This section isn't intended to replace the AutoCAD Reference manual. It focuses on commands from the point of view of drawing a map. The commands are organized as follows: Organizational Commands, Navigation and Display, Drawing, File Management, and Program Extensions. The chapter concludes with a brief discussion of more advanced AutoCAD features and a discussion of AutoCAD and AutoLISP issues for users interested in more sophisticated interaction with their maps.

Organizational Commands

New Maps

To start a new map:

1. Choose **File**>**New**.

   AutoCAD prompts you for a new drawing name.

2. Type a unique name that's easy to remember, then press **Return**.

Don't set yourself up for a disaster — use a name that you haven't used before. You can use the date and month for the last few digits of a name to force it to be unique — for example, *SNOW9512* would be a map in Snow Lake started in December 1995.

Tablet Calibration

Note

Digitize only within the calibrated area — errors are introduced and compounded when moving outside the calibrated area.

Air photo distortion increases towards the edges of the photo, so try and limit digitizing to the central portions of the photo.

AutoCAD directly supports graphics tablets. In AutoCAD a user can lock a digitizer to a drawing mathematically, so that regardless of the current drawing scale or view, data entered on the digitizer is transformed and correctly entered into the drawing.

To calibrate a tablet:

1. Type `tablet` at the command prompt.

   If you have a digitizer properly configured, AutoCad gives you the option of calibrating it.

2. Type `cal`.

   AutoCAD asks you to pick a point. Pick a point on the map that you can accurately find on your screen or that has known coordinates in the coordinate system of your AutoCAD drawing.

Toggle Switches

TABLET MODE **F10** (12R+13R)

TABLET MODE **F4** (14R)

Switching out of TABLE MODE is particularly useful when you want to view/pan over to a segment of your map outside the current screen window.

3. Click a point, placing the crosshair as carefully as possible.

   AutoCAD prompts you for the coordinates.

4. Either type in the coordinates separated by a comma or else click the point on the screen that corresponds to the map point digitized.
5. Repeat this procedure for a second point diagonal from the first, then a third point, and so on (for most maps four points is adequate for digitizing).
6. Press **Return**.

   AutoCAD offers some statistics and asks you to choose between an orthographic, affine, or projective transformation.

7. Choose the affine or projective transformation, or whichever reports the lowest error.
8. Return to the drawing view (press F2 in Windows).

Now check your projection by placing the crosshair on a point you can identify on your screen, but not one that you used for the digitizing process. The cursor on the screen should be on the correct location and the coordinates displayed in the text box on the toolbar should be correct for the chosen point on the map. If not, repeat the tablet calibration with different points. Once you have a good fit, you're ready to begin working with AutoCAD and FieldLog.

Layer

Use the Layer command to:

- Create new layers
- Change the current drawing layer
- Change global characteristics of layers, such as colour and linetype

AutoCAD always draws onto the *current* layer. The name of the current layer is always displayed on the border of the drawing you are working on. Before doing any work in AutoCAD, always make sure that the layer you want to work on is current.

In general, you should use more layers rather than less. It's easy to merge two layers onto one if the need arises, but very tedious to separate one layer onto two. Of course, map items that are associated with FieldLog avoid this problem because the database information can be used to direct the output to a specific layer as needed.

Options with Layer are:

?/Make/Set/New/ON/OFF/Color/Ltype/Freeze/THaw/LOck/Unlock

Most of options require that you know the layer name you want to act on, and the spelling must be exact. The DDLMODES command does the same thing as the Layer command, but works graphically. We encourage you to use it instead. The various Windows AutoCAD versions also present toolbar icons for layer control.

The options for layers are:

?	lists existing layers
OFF	makes a layer invisible to the user, but still accessible from the database
ON	makes a layer visible
Freeze	makes a layer invisible and inaccessible to editing commands
Thaw	makes a frozen layer visible and accessible to editing commands
Lock	makes a layer inaccessible to editing commands; doesn't affect visibility
Unlock	makes a locked layer accessible to editing commands
Color and Ltype	sets default colour and linetypes for the entities on the layer
Make	creates a new layer and makes it the current layer (the layer any new entities go on by default)
New	creates a new layer but doesn't make it current
Set	makes an existing layer current

DDLMODES

This command is a dialog box equivalent of the Layer command. It lists all layers in the drawing, enabling you to easily keep track of the layers you've created and their characteristics. If you click the Layer toolbar this is the dialog you see.

To change the properties of a layer, click a layer name, then an option box.

Note

The *End* command was discontinued in AutoCAD R14.

End and *Quit*

End saves the current drawing and exits AutoCAD. Quit exits without saving, but before quitting AutoCAD gives you the option of saving any unsaved changes.

Undo

Undo reverses the last action performed in AutoCAD.

Undo is useful if you've just erased something important, modified a feature you shouldn't have modified, and so on. Don't use it to undo a mistake in FieldLog. If you do something in FieldLog itself, FieldLog changes the database tables it maintains in the background.Undo doesn't undo changes to database tables, so if you undo something on the AutoCAD map that actually involves FieldLog manipulations of the database, you create inconsistencies between your map and the FieldLog database.

Before using undo, check to make sure the last operation was an AutoCAD operation (like pline, dtext, etc.) and then proceed.

Navigation and Display Commands

Move

Important Note

If you accidentally press Enter when specifying the origin or target location during Move, AutoCAD may move the entity into a remote location far from your map area. Perform an Undo to recover the lost entity.

Move allows you to move objects on the screen. For example, you can move text labels from place to place. You can also move geographically referenced data such as outcrops, but their corresponding database values won't change. To move FieldLog data, use ***Fl-edit***.

Pan

Pan allows you to shift your view of the drawing. AutoCAD distinguishes between the drawing, which is all of the entities you've entered and that have been loaded through FieldLog, and the view, which is your current screen view of that drawing. Because AutoCAD treats all graphic entities mathematically, you can zoom in or out infinitely, although your data quickly falls below or above the scale of the view. Pan allows you to shift the view side to side or up and down without changing the scale. Simply type `pan`, then choose a point. Choose a second point to show AutoCAD where to shift the first point. Try it a couple of times to get the idea.

Zoom

Note

Occasionally the Zoom > E causes your map to appear as a small dot on the screen. This occurs because some entities are at an extreme position far from the map (see note above). You need to delete these outliers before zooming using the extents option again.

Zoom allows you to change the size of the display of your drawing. Together with pan, zoom is the command you'll most often use to get different views of your data. Useful options are:

zoom > **e**	zooms to the entire extent of your current database
zoom > **w**	allows you to pick a new view window with the cursor
zoom > **p**	returns to the previous zoomed view of a drawing, this is useful for returning to a smaller scale view after you zoom in for a close look at something

Some Useful Hotkeys

The following commands can be activated by typing a single letter 'hotkey' and pressing return.

- move m
- pan p
- zoom z
- redraw r
- pline pl
- erase e
- undo u
- circle c
- hatch h

Redraw

AutoCAD frequently clutters up the drawing area with small ticks and lines that represent temporary markers used during editing. To clean up a view, type `redraw`. Although this command is very fast, it doesn't recalculate the view from the database. Setting the AutoCAD environment variable *blipmode* to *off* prevents these ticks from being placed. Ticks however can be useful in tracking the history of recently performed commands — i.e. you can verify that you have moved the proper entity by checking to see if there is a residual tick mark in the appropriate area.

Regen

To force AutoCAD to recalculate a view from the drawing database, type `regen`. AutoCAD frequently does a regeneration when you change the view of the drawing. Regenerations can be quite slow, especially on computers without much RAM. Be prepared to wait a few minutes. Also, in R14 a regen must be performed before raster images, such as geophysical maps, are properly displayed in the background.

List

List allows you to select and display the characteristics of drawing entities. It's useful for quickly determining what layer an entity is on.

Drawing Commands

Line

Don't use this command with FieldLog.

Pline

Important Note

If you type `End` when you're not in a pline sequence, you end your AutoCAD R12/13 session. This isn't a disaster as AutoCAD saves your map when it closes, but you have to load and logon to FieldLog again. You'll have also lost your calibration information and must recalibrate.

Pline is the command you'll use the most when drawing your map. Pline is short for PolyLine. Use pline to draw lines where each line segment connects from the previous line segment's vertex. You can use pline to draw geometric shapes like boxes that have only a few vertices or, by using many vertices, almost smooth shapes like shorelines or rivers. With pline, every time you click with the mouse or digitizer you leave a vertex. To end the command, press Return.

To add a pline:

1. Type `pline`.

   Pline returns *From Point.*

2. Move your pointer to the first location you want a vertex, then click.

   After the first vertex the options change to:

   Arc/Close/Halfwidth/Length/Undo/Width/<Endpoint of line>

3. To add more vertices, just click.

GRIPS

An easy method to edit an entity's shape is to use its grips — boxes placed on top of vertices or at insertion points. To activate the grips, select an entity by clicking it or windowing it. The grips can then be selected and easily moved. Pressing the *esc* key once deselects the grips, and pressing *esc* again deselects the entity and terminates the procedure. In AutoCAD R12, use *ctrl-c* instead of *esc*.

Close draws a line segment from the last vertex to the first vertex of this polyline, closing a perfect polygon. Undo removes the previous segment.

A useful option that isn't listed is End. If you type `End` while in the Pl command mode and then press the spacebar, AutoCAD asks you to pick a vertex. You can pick any vertex on the screen and AutoCAD draws a segment from the previous position to the exact position of the chosen vertex. This is a useful way to ensure that polylines close onto each other — since Close only allows a polyline to close on itself. You can set up

AutoCAD to always try to find a vertex to jump to whenever you click the cursor, a useful feature for making maps — see OSNAP below.

Pedit

Line Widths and Linetypes

In AutoCAD, **line *widths*** can't be changed globally, but must be edited individually at the pedit/width prompt.

In AutoCAD, **line *thickness*** usually refers to the "z" (height) value.

A cartographic quick-fix for changing the linewidths of pre-existing lines is to assign unique colours to layers of lines. Then through AutoCAD's *print> pen assignments* dialog box change the pen default width by selecting the appropriate colour pen and assigning a new value. This change isn't reflected on your screen.

The **pedit/linetype gen** option doesn't refer to changing your linetype, but controls the location of a pattern within a line segment; i.e., do you want your line pattern to start at the beginning of the line, or have it centred over the entire length.

The **linetype** can be preset by assigning a specific line type to a specific layer. When lines are added to this layer they inherit the assigned linetype.

Linetypes can be changed by editing the layer attribute, or by selecting individual lines and using the *chprop* command to modify them.

Scale: you may have to adjust the scale of the linetype in order to see the pattern attributed to the line. This is done using the **ltscale** command. The default value is 1. The lower the value, the more patterns (dashes for example) per line segment.

Pedit allows you to modify an existing polyline. Things you can do with pedit include:

- Assign a width to the line
- Edit a vertex
- Join lines and close polygons

Options under pedit include:

Close/Join/Width/Edit vertex/Fit/Spline/Decurve/Ltype gen/Undo/eXit<X>.

Primarily, you use pedit to join lines, close polygons, change line widths, and rearrange polyline vertices using a pedit submenu called Edit vertex. Options under Edit vertex are:

Next/Previous/Break/Insert/Move/Regen/Straighten/Tangent/Width/eXit <N>:

N	shifts the currently selected vertex (shown on your screen as an X on a vertex) to the next vertex
P	shifts the currently selected vertex (shown on your screen as an X on a vertex) to the next vertex
Move	allows you to move the current vertex
Break	splits the polyline at the current vertex
Width	changes the width of the currently selected line segment

The other options are used less often. Remember that you can use Move and End to move a vertex exactly onto another vertex (to close a polygon, for example).

Other things you might want to do with pedit are override the colour of a line or change a linetype or width. Normally you use width *0* lines in AutoCAD so that lines appear sharp at any zoom. However, you may want to assign lines a definite thickness. This can be useful for emphasizing faults and other features. It's usually better to put all similar features on one layer and make a special linetype for that layer. Read about linetypes in the AutoCAD Reference Manual.

Osnap

Osnap modes, or Object Snap modes, are modifications to the way AutoCAD runs other commands rather than independent commands. Object Snap forces AutoCAD to modify the placement of features such as vertices by referring to the drawing area surrounding the click point and then doing a quick operation. Available operations are *Endpoint, Midpoint, Center, Node, Quadrant, Intersection, Insertion, Perpendicular, Tangent, Nearest,* and *Quick*. The most useful one is Endpoint.

To set the object snap:

1. Choose **Settings>Object Snap**.
2. Select the *Endpoint* checkbox.

3. Adjust the size of the search area using the *Aperture Size* slider.

Until you clear the checkbox in the Object Snap dialog box, any click that's close enough to an existing vertex that the existing vertex falls inside the Aperture box size (there will be a small box around the cursor to show you the size) is shifted to the existing vertex instead of appearing at the click location. This is useful in map production. If the aperture is set relatively small, you can quickly draw polygons and always close them exactly — try to pick an existing vertex and Osnap automatically shifts the click point for an exact match. Try it!

To use Osnap from the command line, type `Osnap`, then type `Endpoint` for the mode. To adjust the aperture size (in pixels on your screen) type `Aperture`. A value of about `12` is a good starting point.

Chprop

The chprop command allows you to change various properties of selected AutoCAD objects. The chprop options are:

Colour/LAyer/LType/ltScale/Thickness

colour	changes the objects' colour
layer	places the objects on a different layer
ltype	changes the linetype
ltscale	changes the linescaling of an object
thickness	this refers to the 'z' value--height

The chprop command overrides the object's existing properties. For ease of editing, maintain cartographic properties at the layer level, rather than varying them object by object.

Text

Text allows you to place a single line of text on a drawing. It requests a start point, a height, a rotation angle, then the text string. To change the font or style of the text, type `Style` at the first prompt rather than picking a start point.

When placing text on a map it's a good idea to place it on a separate layer from the map information. That way annotations can be turned on or off. Multiple text layers (say *placenames, samplenotes, etc.*) are even more flexible. Use layer or ddlmodes to make a layer for text.

Dtext

Dtext allows you to place lines of text anywhere on a drawing. It's identical to the Text command except that it doesn't exit until you press Return twice. Multiple lines of text can be easily entered.

Rotate

Rotate allows you to rotate any drawing entity on the screen using your mouse or digitizer, or by specifying the actual rotation angle. Rotating a structural symbol or other FieldLog entity doesn't change the value stored in the database, only the currently drawn symbol. Use ***Fl-edit*** to change values in the database. Rotate is useful for rotating text to coincide with the alignment of features like roads and rivers.

Copy

Copy allows you to copy entities, one at a time, or place multiple copies of the same entity at different locations.

Scale

Scale enlarges or shrinks the selected entity. Values between 0 and 1 reduce the entity size, whereas values>1 increase its size. For example, an object scaled .5 is 1/2 its original size and an oject scaled at 4 is 4 times its original size. The x and y aspect ratio remains unchanged. When multiple entities are scaled, an origin is selected and all entities are scaled relative to this origin. This means that the absolute location of all entities changes — a very dangerous side-effect. FieldLog's ***fl-scale*** command overcomes this problem.

Erase

Erase allows you to select and erase drawing entities. Using the mouse, you can click on objects to build up a set to erase. Pressing *Enter* deletes the selected entities. Undo (u) deselects the most recently selected entity. The window (w) option allows you to build a selection set by drawing a box. To terminate the erase command, use *Ctrl+C* (R12/13) or press *esc* for R14. If you erase something you want to keep, use the undo command.

File Management Commands

Save

Save saves your file to disk quickly. It doesn't prompt you for a filename unless this is the first time you've saved the file. Save your work often! Save doesn't back up your FieldLog database. FieldLog data is automatically saved when entered.

Save As

Save As allows you to save a drawing under a new name. This is useful if you want to generate multiple independent backups of a drawing. Save As does NOT backup the FieldLog database — it only saves the drawing part of the file. If you use Save after Save As you'll replace the second version of your file, not the original file. When a Save As is performed, AutoCAD changes the name of the currently open drawing and leaves the original drawing untouched on disk.

DXFOUT

DXFOUT allows you to export a DXF file. DXF is the standard CAD (and low-end GIS) way of exchanging spatial data — you can import a DXF into CorelDRAW or Illustrator, for example, to make slides for a presentation. DXFOUT opens a dialog box and asks for a filename and directory. It then asks for decimal places of accuracy (6 is often sufficient, unless you are importing into a GIS where maximum accuracy — usually 16 — is desirable) and proceeds to write the file to disk.

DXFIN

DXFIN allows you to import a DXF file. DXFIN opens a dialog box and asks for a file name and directory. It then brings in the entities from the file and places them on the view at appropriate places. When making maps you can get bizarre results if you DXFIN a file from one map projection into another map projection — AutoCAD doesn't directly support map projections. To get around this, import the DXF into an empty drawing, project it using ***fl-project*** into the desired projection, save the reprojected version, and then insert the new drawing into the original using *INSERT*.

WBLOCK

The *WBLOCK* command writes a block or the entire drawing out to a disk file, creating a new DWG file. Use this command to get blocks used for symbology out of one DWG file and into another. If an entire drawing is exported, it can be inserted as a block into another drawing — this is an easy way to create composite maps where one map is at a different level of detail than another.

INSERT

Inserts a named block onto the map, allowing the user to specify rotation and scale as desired. If a drawing is named, the entire drawing is converted into a block and written into the file on the fly.

Advanced Issues

Blocks and Attributes

WBLOCK vs BLOCK

BLOCK groups objects for use in a current drawing file only. WBLOCK extracts drawing entities into a separate drawing file. This drawing file can then be inserted into other drawing files. For example, a digitized obscure symbol not found in any resident FieldLog shape library could be saved as a *wblock* and then inserted whenever necessary into your current drawing file.

Blocks are structures in AutoCAD that are built up out of smaller drawing entities. An example might be a north arrow (with an N and an arrow) or a template for a drawing name, date, and author. Any number of entities may be included with a block, up to and including an entire drawing!

To make a block:

1. Make sure all of the related entities are visible, then type `block`.
2. Type in a unique block name.
3. Enter a base insertion point, which is the point on the block that the aggregate is inserted around. Try this out, it isn't exactly intuitive.
4. Select the objects you want included in the block.

   The entities disappear. Don't worry. They went into the block database. To replace them, insert the block.

To insert a block:

1. Type `Insert`, then the block name.
2. Enter the insertion point, followed by a scale factor (1 for X, 1 for Y unless you want the block size to change), and a rotation angle (0 to leave the block unrotated).

   AutoCAD inserts the block.

Attributes are user defined data that are embedded within a block. You can put text or numeric fields with prompt names inside any block. When it inserts a block, AutoCAD prompts you for values for the attributes. This is a simple way to build up a database map combination. We don't recommend it within FieldLog, as FieldLog provides more

sophisticated ways to build a database than simple attributes. See the Attributes section of the AutoCAD Reference Manual for more information.

Before you make a block and attribute set, consider carefully: FieldLog is designed to provide symbol-database combinations exactly like blocks and attributes, but much more powerfully and simply. If the needed changes can be made via a FieldLog table, consider going through the Setup process and including the new item in your FieldLog database rather than maintaining two separate database systems. A general rule is: if the data is geological, it should be in FieldLog.

FieldLog maintains symbols as either blocks or shapes in AutoCAD drawings. However, prior to using with FieldLog, all symbols must reside in shape libraries that are loaded by FieldLog before any symbols are plotted to a drawing. Refer to the Appendix A for instructions on how to create shape libraries.

XREFs

There are times it's useful to temporarily include material for other drawings in a FieldLog map. The XREF command allows the contents of any AutoCAD drawing to be attached as background to a drawing in use. The attached reference drawing can't be edited, but can be temporarily modified in display color and behavior by the DDLMODES command. All layers in the attachment appear with their drawing name as a prefix.

As long as the projection parameters of the attachment and the drawing are matched exactly, XREF can be useful; if the two drawings are projected differently they don't superimpose properly and XREF is useless.

Explode

If you need to disassemble a symbol or user block in AutoCAD, use the Explode command to select and break up the block. If a FieldLog database record is attached to a block, then that linkage is lost upon exploding. However, for blocks such as stereonets, FL creates links to the entities inside the block where exploding the block exposes the database links and permits the database contents associated with them to be browsed with ***fl-edit***.

Summary

AutoCAD contains a great variety of commands for making accurate drawings, many which are useful for making geologic maps. This chapter covers the essential commands. In addition to knowing the commands, effective map production involves organization and planning. The key points in building maps in AutoCAD are:

1. All data must be in the same map projection and datum, with the same projection parameters.
2. Whenever possible, put thematically distinct information on seperate layers.
3. Distinct sets of layers such as topographic bases can be kept "pristine" and imported into working maps with XREF.
4. Document your work, and backup often!

CHAPTER 7

Customizing FieldLog

Introduction

FieldLog provides support for field data capture through a *data model* well suited to the needs of most field geologists. The *data model* provides building blocks for the construction of personal database structures in which the field data resides. For example, the database used in this tutorial (*SnowLake*) exemplifies a data structure well suited for the needs of survey geologists interested in capturing a wide variety of field observations and dependent laboratory results into a single data management system. This example data structure is also populated with real field data.*

Your needs may be substantially different from those of the workers in the SnowLake area. This might include differences in symbolization, differences in terminology and classification schemes, and differences in depth of detail. This chapter assumes that you want to make minor changes to an existing FieldLog project, and briefly introduces customization of the palettes, profiles, and table structure within a project.

Warning

Changes to the fundamental structure of FieldLog can lead to unanticipated adverse side effects. Before customizing FieldLog, back up your database completely. Once a change has been made, take the time to do a wide variety of queries, data entry and editing examples, and map editing before attempting major work with the modified system.

* Bailes, A.H., and Galley, A.G., 1993, Geology of the Anderson-Stall volcanic-hosted massive sulphide area, Snow Lake, Manitoba: Geological Survey of Canada, Open File 2776, 1 map, scale 1:10,000.

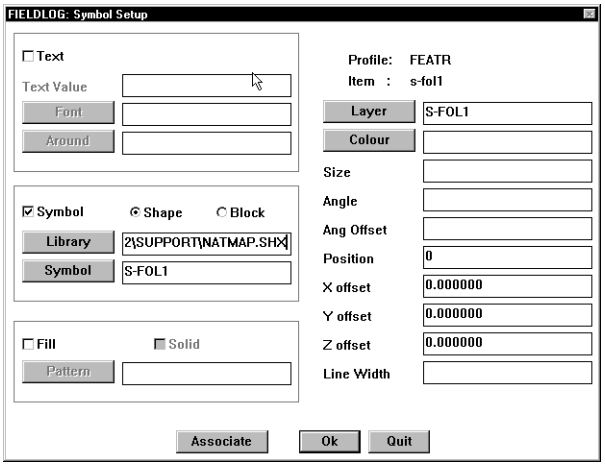
Customizing FieldLog Palettes

At some point you may want to modify the way that FieldLog symbolizes data to the map. The Palette controls the display characteristics of items as they are plotted to the map.

For example, the possible variables in a palette specification are:

- Text value and font, if text is to be printed
- Symbol library and symbol name, if a symbol is to be printed
- Layer the new entity should be placed on
- Colour of the new entity
- Size of the new entity
- Orientation angle of the new entity
- Angular offset
- Position of a text item around a symbol
- X,Y,Z offsets relative to station location
- Line width, for entities with controllable line width
- Solid or pattern fill type for the wedges of a pie diagram

These options are contained in the Symbol Setup dialog, shown below:



Palette controls can be associated with various parts of a database setup, permitting groups of database items to share a Palette control. If every possible combination of layer, colour, symbol, orientation and so on had to be set for every possible entry in an entry field, database setup would be incredibly tedious. This is alleviated by allowing you to specify symbology at different levels of database setup.

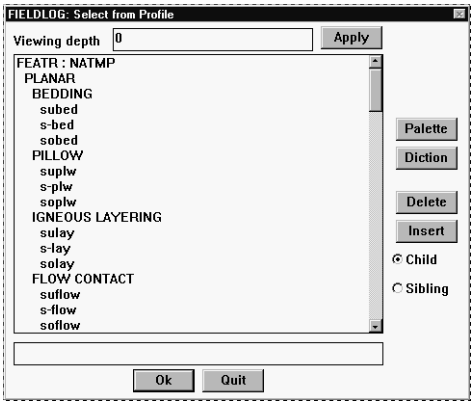
Palettes and Profiles

FieldLog allows symbol palettes to be assigned at two levels: first, any column in a table may have a palette attached to it. Second, any item in a profile may have a palette specification.

FieldLog's data entry and data query processes are column-based: data is added to tabular rows, which consist of columns, and queries return a table of columns. Even FieldLog's dictionaries and profiles are attached to columns. More significantly, columns are selected for plotting in both the data entry and query procedures. Thus, when a symbol is to be plotted, FieldLog first inspects the column's (e.g. *Rocktype* in *LITHO*) Palette parameters and utilizes those that are specified. For those parameters without a value at the column level, FieldLog reads the data item in column (e.g. *monzogranite*) and checks in the profile to see if a Palette value has been defined for the data item. If so, then it tries to find the missing symbol parameters here. If some parameters are still not found FieldLog traverses up the hierarchical profile searching for them in the Palette definitions of any parent profile items (e.g. in *Granite* and *Igneous*). If no symbol or text parameter is specified in this process (though other parameters could be defined), FieldLog simply prints the data item as text onto the map.

For example, as shown in the figure on the preceding page, *s-fol1* is present in the palette, has a specified symbol from a specified library, and will be placed on the layer *sfol1*.

If there is no value in the palette attached to the profile entry, FieldLog examines the palette for the entry that is the *parent* in the profile hierarchy (i.e. *Foliation*) to the original data value. It continues to move up the hierarchy (i.e. to *Planar*) until the top is reached, or until a value is found.



At first look this structure is quite complex, but consider this: instead of specifying *for each structural symbol in the profile* how to rotate to the correct azimuth, this is simply set in the column's palette. Instead of explicitly designating the position of text, such as the dip or plunge, *for each structural symbol in the profile*, these can be assigned to the *Planar* and *Linear* items and thus inherited by the remainder of the structural items in the profile. This resulting system is both flexible and powerful.

Symbols

Symbols in AutoCAD are built from individual line segments or other graphic entities and reside in libraries that are named with *.shx* extensions.

The FieldLog distribution comes with three Canadian structural symbol libraries, *OGS.shx, GSC.shx, and NATMAP.shx,* offering a great variety of symbols.

If you need to define your own shape libraries, refer to Appendix A and experiment with the programs for manipulating symbols: *SHX2DXF.EXE* and *DXF2SHX.EXE*

Using Palettes

When modifying or setting up palettes, remember that the purpose of the hierarchy of symbol palettes is to avoid having to make a new entry in multiple places. If you are symbolizing a group of symbols, anything common to the group belongs either in the column's palette, or perhaps in the profile parent's symbolization.

One of the most powerful features of palettes is that they allow *dynamic symbolization*, where the symbols on a map convey multiple meanings through the use of the available cartographic variables (typically colour, size, orientation, symbol type, and lineweight). In a traditional map, a structural symbol conveys orientation through orientation, type of structure through symbol type, and dip through associated text. A dynamic symbolization might colour structural symbols to reflect steep and shallow dips, and avoid using the dip text totally.

There is no limit to the number of possible dynamic symbolizations of a FieldLog dataset. However, bear in mind that a map that others must use must have either recognizable, standard symbols or else a very clear legend.

Example of Modifying Palettes

To look at both the symbolization process and dynamic symbolization, we'll make some basic modifications to the symbol palette for the structure table in *SnowLake* and examine the results.

Before You Begin

If you aren't logged on to FieldLog and the *SnowLake* database, follow the steps from Chapter 2 to open *snowlake.dwg* and log on:

- Start AutoCAD, then open *SnowLake.dwg*.
- Load FieldLog using the menu.
- Logon to the *SnowLake* database using fl-logon from the AutoCad command line or the FieldLog menu.

At this point you should have a map of the SnowLake area displayed. Zoom out to view the entire map before you start the palette tutorial.

Simple Palette Changes

In this exercise we'll change the palette for structural symbols so that all planar structures plot in red and all linear structures plot in green.

1. First, zoom in to an area where you can see an existing structure. Type `fl-add` at the command prompt or select it from the menu, and select the *STRUC* table.

   Notice palette button near the bottom of the dialog box. This is how we'll access the palette.

2. Select the *Feature* column in the table, then click the **Palette** button.

About Structural Measurements

Structural observations are representations of the three-dimensional orientation of observed features. Since a simple observation of strike and dip by itself is ambiguous (does a strike of 80 degrees mean that the object dips off to the right or left?), a common method for recording structures is to record planar structures such that when looking in the direction of the strike, the object dips off to the right. This is informally known as the right-hand-rule. Using this system, strikes range from 0 to 360 degrees, and dips from 0 to 90 degrees.

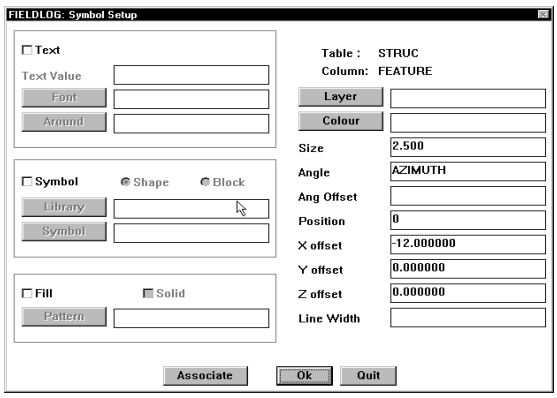
For linear objects, record the trend as the facing direction when the object plunges away and down, and the plunge as the angle at which it drops below the horizontal.

Alternatively, FieldLog supports the dip-direction method of recording planar structures, where the trend and plunge of the steepest line in the plane is measured as a lineation.

AutoCAD Symbol Positions

AutoCAD places text around predefined symbols using a simple 8-position system. In this notation, a 1 indicates that the text is placed to the right, a 3 to the top, a 5 to the left, and a 7 to the bottom. The even numbers represent the diagonal quarters.

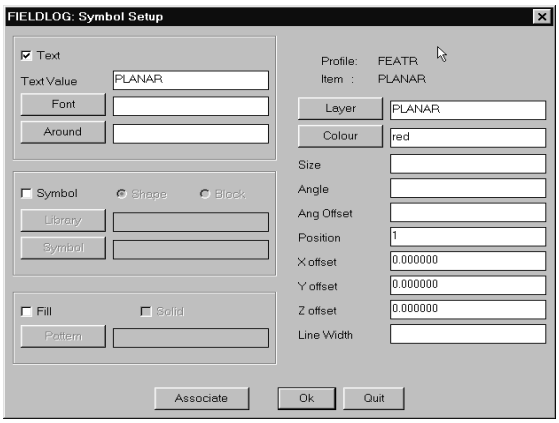
The Symbol Setup dialog box should appear.



Notice that there is a section for colour. What happens if we pick a colour here? That colour is subsequently used for all plotted structures as it overrides the colours specified in the AutoCAD layer setup.

3. Since we want to set two different colours, not one global colour, leave the dialog box by clicking **Quit**. We need to control palette symbolization through the profile for structural data because that's where different types of structures can be symbolized independently.
4. After returning to *fl-add*, with the Feature column still selected, click the **List** button. The hierarchy browser for the structural palette appears.

   Since we want to use colour to distinguish between *Planar* and *Linear* features, only these items need to be symbolized in the hierarchy. There is no need to set the colour for any of the *child* items of *Planar* and *Linear* as FieldLog moves up the hierarchy and finally reaches the *Planar*/*Linear* items and their colours. Also notice that the position of text around a *Planar* feature is set to 1 — this indicates that associated text (such as dips or plunges) plot immediately beside any *Planar* symbol.
5. Click **Planar**, then the **Palette** button.
6. Click the **Color** button, and choose *red* from the choices offered.
7. To return to the hierarchy browser, click **OK**.



8. Now set the color of linear structures to green. Notice that the position of text around a *Linear* feature is set to 3 — this indicates that associated text (such as dips or plunges) plot immediately above any *Linear* symbol. Press **OK**.
9. Return to the browser, click **OK** and exit to *fl-add.* Quit *fl-add.*
10. Run a query using *fl-query* to display all structures (you should be able to do that by now! If not, see chapter 4) Note that they plot in red and green dependent on type.

We've just seen that the symbolization controls in FieldLog allow customization that supports dynamic symbolization for making thematic maps.

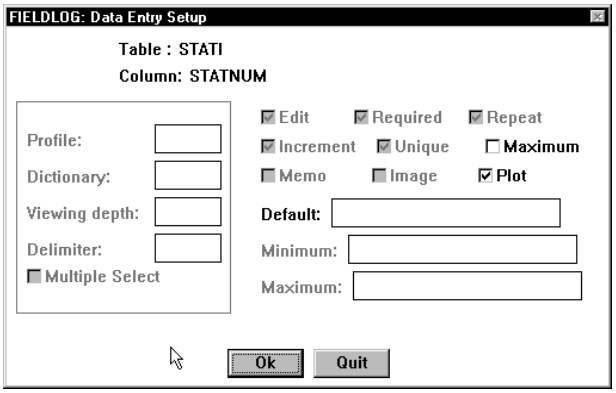
Controlling Data Entry with *Input*

Making New Profiles and Dictionaries

Once you have created a new profile and dictionary, you need to fill it with valid entries. After exiting Data Entry Setup you should see that the *list* item is available in *fl-add* and *fl-edit* for this column. You can now use the *Insert* and *Delete* buttons within *List* to populate your profile. See the notes on Profiles, below.

One of the key problems facing geological database builders is quality control. Misspellings, informal terminology, and missing data can cripple a GIS database. FieldLog has two methods for dealing with this problem. First, profiles and dictionaries act as on-line references for spelling and meaning, and allow typing to be replaced by selection from lists to avoid spelling errors. Second, FieldLog supports controls on all columns in all tables that restrict data access types, force columns to be completed, and do simple checking on entered data.

The input controls are accessible from *fl-edit*, *fl-add*, and *fl-setup*. For the *statnum* field of the *STATI* table, the data entry setup dialog box contains:



The Table and Column referred to are indicated at the top of the dialog box. The main features of the dialog box are:

- Profile Name: if a profile is attached to the column, it's named here.

  To attach a new profile, simply name it here and a table is created automatically once the **OK** button is clicked. If the option is greyed out, adding a profile is unavailable except through setup, or is inappropriate for this column type. To attach a new profile, you must also define a new dictionary. Profile names are a maximum of 5 characters long.

- Dictionary Name: if a dictionary is attached to the column, it's named here.

  To attach a new dictionary, name it and a table is created automatically once the **OK** button is pressed. If the option is greyed out, dictionaries are

unavailable for the column highlighted. Dictionary names are a maximum of 5 characters long.

Uniqueness

FIeldLog stores two fundamental types of information in its tables: field data and setup information (i.e., information about how the database and project are configured).

Part of the configuration information for each table is the *Unique Number.* FieldLog requires a numeric column, called the *Unique Number*, to exist in each table and to contain unique values. This provides the system with an unambiguous way of referring to a row, and hence to a field observation, in a table.

Other columns, such as the station number column in the STATI table, may also be unique.

For more details on relational databases and FieldLog, see Appendix B.

R13/14 Note: Images

AutoCAD R13 and R14 support the direct incorporation of images into a FieldLog database. Supported file formats are:

R13: TIFF, GIF, TARGA (TGA)

R14: TIFF, TGA, BMP

- Viewing Depth: specifies the number of levels visible in the profile browser.
- Delimiter: specifies the character used to separate multiple choices for a profile.
- Multiple Select Checkbox: indicates that the current column may contain multiple entries separated by a delimiter.
- Edit Checkbox: indicates whether the current column is editable.
- Certain fields are used internally by FieldLog, and should not be modified by users. The unique number is an example of this.
- Required Checkbox: specifies whether the column must be filled in.
- Required fields are a crucial tool for ensuring that a minimum level of data is collected and recorded; e.g., *STATI.Statnum*.
- Repeat Checkbox: forces FieldLog to repeat the last value entered into this column when a new record is created; e.g., *TRAV.Fieldate.*
- Increment Checkbox: forces FieldLog to repeat and increment by one the last value entered, when a new record is created. Used to automatically increment unique numbers; e.g., *STATI.Statnum.*
- Unique Checkbox: forces FieldLog to check that an entry is unique, in order to prevent duplicates occurring; e.g., *STATI.Statnum.*
- Minimum and Maximum Boxes: forces FieldLog to enforce minimum and maximum values for numeric fields. The actual limits are indicated in the boxes; e.g., *STRUC.Azimuth.*
- Memo Checkbox: indicates that the column is a memo, where a multiple-line message can be typed.
- Memo fields are very useful for recording descriptive text. Though they can be exported to text files, they can't be searched. Unlike many GIS and database systems FieldLog's memo fields are completely compatible with all SQL compliant databases; e.g., *LITHO.Comment.*
- Image Checkbox: indicates that the column contains a reference to an image file which can be viewed using the *Image* button. This is inactive with AutoCAD R12, but available in R13-14.
- Plot: indicates that the selected column is to be plotted to the map during data entry. This box may be overridden by the Plot button in the *fl-add* panel. The Input>Plot option doesn't affect which columns are to be plotted from a query, as those are selected at query time; e.g., *STRUC.Feature.*
- Default: stores the default entry for the column. This value is automatically placed in the column during data entry; e.g. *TRAV.Fieldate*.

There are obviously many controls here that can affect how data entry progresses. The most crucial for day to day work are the *required* and *unique* checkboxes. These can be used to enforce a minimum level of detail and to prevent index numbers, such as lab sample numbers, from being entered incorrectly.

FieldLog Dictionaries and Profiles

Short Name Abbreviations

You can use short names during data entry. You type the short name and FieldLog automatically replaces it with the long name. In fact, only the unique part of the short name must be entered for FieldLog to determine which long name is being referenced. This greatly speeds data entry.

Perhaps the most revolutionary feature of FieldLog is the incorporation of terminology dictionaries and profiles into the basic operation of the program. Dictionaries and profiles allow organizations and users to control the use of terminology during the creation and upkeep of a database, and can thus ensure some level of uniformity across large projects. Since the dictionary/profile combination is a set of standard database tables, they can be distributed between projects to enforce standards organization-wide. One common implementation of this involves the creation of corporate dictionaries and profiles, where the corporate profile is a core subset of terms from the a corporate dictionary, arranged in a hierarchical manner. Geologists are encouraged to retain this core during daily operation, but they may evolve the lower levels of the hierarchy to meet individual and project needs. Thus a degree of corporate uniformity is maintained without sacrificing flexibility of use.

The dictionary is in fact a form of *metadata* that store definitions, abbreviations, and long forms of common geological terms. Dictionaries enforce not only common spelling of a term, but also provide an easy way to check definitions, and so support a uniformity of *usage* of terms, a much more difficult problem in large GIS projects.

The profile is essentially a hierarchical view of the terminology within a dictionary. It also links to palettes to provide controls on symbology, and links to the dictionary to provide access to the meaning of the terms. Arranging geological terms hierarchically is crucial in recording and, especially, analysing geological observations, since the inexact nature of geological fieldwork virtually guarantees that descriptions will be more specific in well exposed and geologically clear-cut areas, and more general in poorly exposed or highly ambiguous areas.

As FieldLog can search within hierarchies, using the *fl-query* tool, it's possible to analyse data despite differences in the level of classification. For example, a hierarchical query looking for granitoids would find not only rocks labelled as granitoids, but also rocks that were more specifically *types* of granitoids.

Examples of Using Dictionaries and Profiles

Although Dictionaries and Profiles can be created, modified, and deleted using advanced tools in *fl-setup>Dictionary Setup*, you can make basic changes to existing Profiles using the Profile browser, accessed with the **List** button on the *fl-add* panel. You can also create new Profiles using the **Input** button. This allows you to modify Profiles during data entry to reflect new terminology and create new Profiles when a column in a table could benefit from a classification system.

Before You Begin

If you aren't logged on to FieldLog and the *SnowLake* database, follow the steps from Chapter 2 to open *snowlake.dwg* and log on:

- Start AutoCAD, then open *SnowLake.dwg*.

- Load FieldLog using the menu.
- Logon to the *SnowLake* database using *fl-logon* from the AutoCAD command line or the FieldLog menu.

At this point you should see a map of the SnowLake area. Zoom out to view the entire map before you start the dictionary/profile tutorial.

Dictionary Access

1. Use fl-add to add a new station on the map, using the following values:

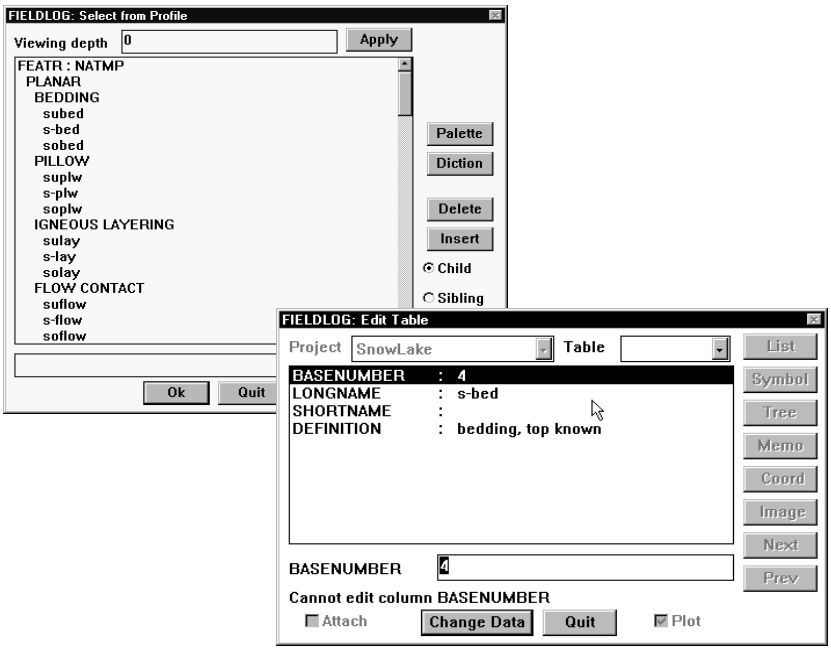
UTMX, UTMY, UTMZ	leave blank
Station Type	Outcrop
Station Number	me4
airphoto	none
Traverse Number	30
Outcrop Number	none

2. Add a structural observation for this station, using the following values. **Don't** click **Enter Data** when done.

Station	me4
Feature	s-bed
Azimuth	123
Dip	54

3. Let's assume that in this case we want to check on the exact meaning of *s-bed* in the dictionary. Select the *Feature* column, and then click the *List* button.
4. In the *Select from Profile* browser, choose *s-bed*, and then click the **Diction** button.

The *Edit Table* dialog box appears, with the dictionary definition for *s-bed* listed:.



Note that no short form is defined. Also, since this is a simple table just like all other FieldLog tables, it is viewed in the standard *fl-edit* dialog.

The dictionary items could be modified at this point, but we'll leave them intact.

5. Click the **Quit** button.

Profile Modification

Misspelled Profile Items

To correct a misspelled profile item, you must delete it and insert a correctly spelled item.

We'll now modify the structural profile to include a specialized type of bedding — an observed crossbed, *xbed.* This means defining the relationship of *xbed* to other items in the profile and creating a new dictionary entry for the term.

1. Access the structure entered in the last exercise using *fl-edit.*
2. Select the *feature* entry. To open the Profile browser, click **List**.
3. Select *s-bed.*

   We'll introduce a special case of the *s-bed* symbol, *xbed*, which is a *child* of *s-bed*.

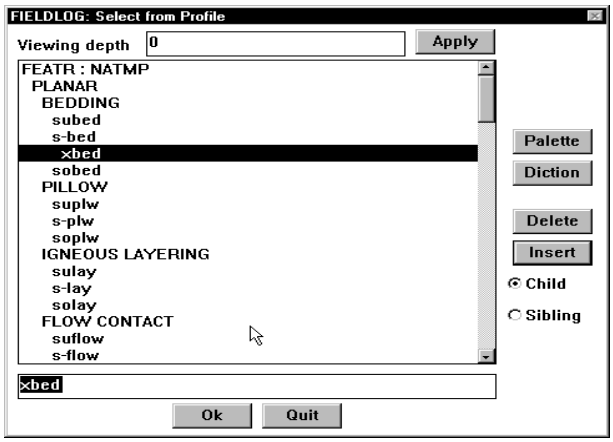
4. To force FieldLog to enter the new Profile entry as a child of the currently selected item, click the **Child** radio button.
5. Enter `x-bed` in the data entry field at the bottom of the dialog.
6. To place the new item, *xbed*, into the profile, click **Insert**. Fill in the dictionary item with a definition for the new term (e.g., Longname = *x-bed*, Shortname =*xb*, Definition = *cross bedding*), and click **Change Data**.

Saving the Setup

Once you have changed a profile or dictionary, you should force FieldLog to save the changes in case there is a crash.

From the *fl-setup* button menu, choose *Save FieldLog Setup.*

You should now see a new subtype of *s-bed:*.



7. To force the change into the *fl-edit* dialog box, click **OK**, and then **Enter Data** to commit the change to the database.

   Note: Prior to plotting an x-bed to the map, you must specify a Palette definition for it. To do this, use the **Palette** button as described above.

A properly constructed set of profiles and dictionaries can make a big difference in the internal consistency, and thus utility, of a field geological database. Field terminology is itself inherently hierarchical, and so by treating this hierarchical organization explicitly, FieldLog provides unique tools for geological analysis.

Modifying FieldLog's Table Structure

Palettes, profiles, dictionaries, and input controls determine how data is entered into a series of tables to produce a self-consistent, geologically useful database, and how items from this database are plotted to the map. But the actual data content is also controlled by the table structure of the database, which is built from logical building blocks (the FieldLog data model) that reflect the mapping process. From these building blocks geologists can construct databases that are tailored to individual and specific project needs. As discussed in Appendix B, data models are adapted to specific applications, but generally have a common overall structure. This reflects the fact that while we are all collecting field data for specific purposes, there are large commonalities in fieldwork in general.

For example, in the SnowLake database, the following tables are central:

- TRAVerse table

  This table provides a place to record information that describes and documents a traverse, which often comprises a day's work, but at the very least is a thematic series of stations.

- OUTCRop table

  The Outcrop table records groups of stations that are geographically linked to a single outcrop. A single outcrop may have any number of associated stations

- STATIon table

  The station table stores location and identification information describing a station, the site of a series of geological observations. Multiple stations can be associated with a single traverse or outcrop.

- LITHOlogy table

  The Lithology table hosts information about a rock type observed at a station. It contains rock name and various descriptive physical attributes. Multiple lithologies can be associated with a single station.

- STRUCture table

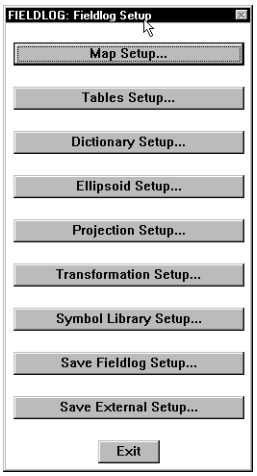
  The Structure table records structural data, including type and orientation details. Multiple structures can be associated with a single station. Alternatively, structures can be associated directly with a specific lithology, allowing analysis showing the relationship between lithology and structures present.

- SAMPle table

  The Sample table is derived from the lithology table and records information for collection purposes. For instance, samples collected may be for geochemistry, geochronology, petrology, or oriented for structural purposes. Multiple samples can be associated with a single lithology.

- LEGND table

  The Legend table stores map legend information, including age relations and stratigraphic nomenclature. It's used in assigning regional nomenclature to a set of map data.



- MINERal table

  The Mineral table records specific instances of minerals observed in lithologies. Multiple mineral observations may be associated with a single lithology.

- CHEMistry table

  The Chemistry table is an example of a data source that is from outside the field environment, in this case from a geochemical survey associated with specific samples. Although this data originated as a spreadsheet from a lab, it has been seamlessly imported and incorporated into the *SnowLake* project.

- UNITS table

  The Units table records positions at which labels may be placed to uniquely define polygons for the construction of a polygonal geological map. When exported to a desktop GIS, the Units table is used to attribute polygons constructed from AutoCAD linework.

- PHOTO table

  The Photo table catalogues photographs taken in the course of field mapping. FieldLog operating within AutoCAD R13 and R14 permits digital versions of the photographs to be displayed from the database if the digital filename is stored within a column and if that column has been designated as an *Image* using the **Input** button.

These tables divide the normal data collected in a field mapping project into pieces that are *related* by identification numbers (e.g., station number, sample number, lab number, and so on) to generate a single flexible structure. The exact fields, or columns, present in each table vary depending on the needs of the

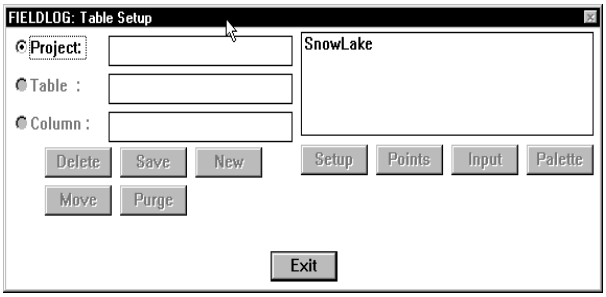
organization: the *SnowLake* database is for government geological survey style mapping. Most often, modifying this structure for your own work involves adding fields to tables; the overall table structure is usually constant.

Changing the table structure is a straightforward process in FieldLog, and is managed by **Fl-Setup>Table Setup**.

Example Using Table Setup

As an example we'll examine the table structure underlying the *Sample* table.

1. Choose **FieldLog>Fl-Setup**.
2. Choose **Setup>Table Setup**. The Table Setup dialog box appears.

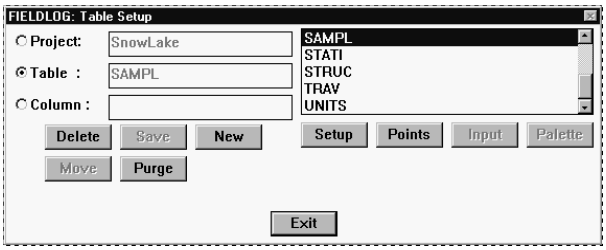


Use the radio buttons to select the project, table, or table column to modify. To select a table, a project must be first selected. Type *Char* indicates that this is an alphanumeric field. Length *1* indicates that only a single character is recorded. *Decimals* is in this case are irrelevant. The alternative choices for *Type* are variations on numeric types, including floating point, real, and integer values in various precisions. To exit column setup, click **Quit**.

R13-R14 Note

In AutoCAD R13 and R14 there is an additional button in the Fl-Setup menu bar. *Project Setup* is used to establish links between AutoCAD and FieldLog projects. In AutoCAD R12 this is done by editing files directly. See Appendix A for details.

3. Select the *SnowLake* project. Click the **Table** radio button. A list of available tables appears.



Note that at this point the **New** button is available, allowing us to create an entire new table. However, if you enter a table name and try and save it, FieldLog returns an error message — you must create at least one column for the new table before FieldLog allows you to save your setup (column setup is discussed below).

The Delete and Purge Options

Delete makes FieldLog unaware of the table, and also permits you to permanently erase the table and its data. Use *Delete* with great care. *Purge* is a house-keeping operation that will eliminate deleted rows, that are invisible to you. This compresses the table and improves database performance. It is worthwhile to occasionally perform this operation on your database; but note that purged items cannot be recovered, so use it cautiously.

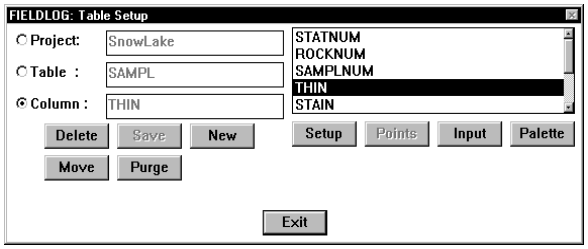
4. Next, select the *Sample* table by clicking *Sampl* in the list of tables.

   Notice that the **Delete** and **Purge** buttons are now available. Also available are the **Setup** and **Points** buttons; these are discussed below in the Table Registration and Points Registration sections.

5. Click the **Column** radio button.

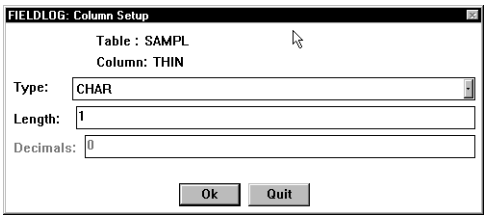
   The list at the right now shows the columns in the table that are available for editing.

   Here we have selected the column *Thin*, which records whether or not a particular sample is intended for thin sectioning.



Note that the **Delete**, **New**, and **Move** buttons are now active. These act on the selected column, performing the indicated action: **Delete** removes a column from the table, **New** creates a new column (type in a new column name and press Enter), and **Move** moves a column from its current position to a new one.

On the right, we now have access to the **Setup**, **Input**, and **Palette** buttons. Input and Palette are for setting default input controls and palette settings, respectively, as discussed earlier in this chapter. Setup controls the data type parameters for the indicated column. For example, the *Thin* column has the characteristics:



6. You can add a new column to the Sample table by clicking **New**, typing a column name, and pressing *Enter*.
7. The new column name appears at the bottom of the column list, in the right panel. FieldLog assigns it a data type of *Char* and a *Length* of 6. To modify these, click to select the column, and then use the *Setup* parameters to alter the default data type. Finally, click **Save** to save the new table structure.

Table Setup and Registration

Although many of the characteristics you set when creating a table are at the level of columns, such as data input controls and profiles, the most complex setup process is to actually determine the logical place of a new table in the FieldLog data model. This is done using the Setup button once a table has been selected from the table list; the Table radio button is then active.

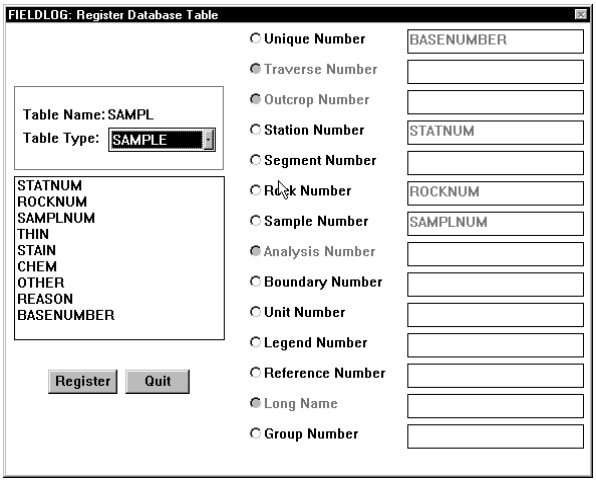
As an example, we'll examine the overall setup of the Sample table and its place in the FieldLog data model.

1. Return to the *Table Setup* dialog box, and then select Project *SnowLake* and Table *Sampl.*

   At this point the Delete, Purge, and New buttons, and the Setup and Points buttons become accessible.

   Points is a special button that allows us to tell FieldLog that a specific set of columns in a FieldLog table contains coordinate information, and to define the projection system for that information. We'll return to this shortly.

2. Click the **Setup** button. The *Register Database Table* dialog box appears. This is a complex dialog, and we only examine it superficially.



This dialog is roughly divided into three sections. The lower left displays the available columns in the selected table, in this case *Sampl*. The upper left chooses the table *type*, in this case a Sample Table. The right section permits the assignment of columns from the table to the required logical components in the data model. This allows FieldLog to link tables within a database.

For example, each FieldLog table must contain a numeric column which in turn contains unique numbers for each row in the table. The Unique Number edit box in the right panel represents this logical entity. For FieldLog to be able to use a table it must know which actual column in the table represents this unique number concept. In the *Sample* table the column containing unique numbers is called *Basenumber* and thus *Basenumber* appears within the Unique Number edit box.

For the FieldLog data model to be practical, it requires one or more other links to be specified between tables, depending on the type of table. These links are represented by the Traverse Number, Outcrop Number, Station Number, and so on, concepts listed in the right panel. When a table type is chosen some of these links become activated, indicating the possible links available. Of the activated links, some are mandatory and others are optional. FieldLog doesn't permit the table to be registered until all mandatory links are specified. The actual column in the table that corresponds to an activated link may be specified by selecting the link, typing the name of column into the edit box beside the link or, alternatively, clicking the column name in the bottom left panel, automatically placing the column name in the edit box of the selected link.

As a general rule, the closer the table is to the 'top' of the list, the more required links will exist. The *Sampl* table, (previous page), has relatively few requirements. It must have:

- A unique number for record identification, usually called *Basenumber*
- A placeholder for FieldLog to store Station Numbers, to keep samples associated with their source stations

- A sample number, to store the data recorded on the sample for human identification purposes
- It may optionally also contain a Rock Number to associate the sample with a specific lithology observed at the station

Most tables require not only a *unique number*, but also one or more other key columns to uniquely identify the table. For example, the *statnum* column uniquely identifies the *STATION* table, though *STATION* also contains a *basenumber* column as its unique number.

Required key fields for the table types include:

- ANALYSIS: unique, analysis, and station numbers
- SAMPLE: unique, sample, and station numbers
- COMPOSITION: unique and station number; optionally rock number
- GENESIS: unique and station number; optionally rock number
- ROCK: unique and station number
- SEGMENT: unique, station, and segment numbers
- STATION: unique and station number; optionally traverse and outcrop numbers
- OUTCROP: unique and outcrop number; optionally traverse number
- TRAVERSE: unique and traverse number
- BOUNDARY: unique and boundary number
- UNIT: unique and unit number
- LEGEND: unique and legend number
- REFERENCE: unique and reference number
- DICTIONARY: unique and item name
- OTHER: unique

Of course, you may want to include other links to create a more highly interrelated database setup. For example, linking in a *Unit Number* would allow a direct association between the geological unit and the sample. The degree to which you interrelate information in the database is a reflection of the needs of your project.

FieldLog provides a powerful environment for storing data, at the cost of a data model that requires care and handling. When working on the table setup for a project, be sure to do a backup, and test the changes thoroughly before returning to normal use.

Grouping Data

If you are doing detailed mapping in geologically complex areas, you may want to group various observations. For example, you may want to group related foliation and lineation measurements in a location where each lineation exists on the plane of one of the foliations. *Grouping* is particularly beneficial when you are plotting your data to the map from a query. If you don't group your data, all structural data for that station plots directly on top of each other, making it impossible to discern which lineation goes with which foliation, unless you have

your note book or the FieldLog database open in front of you. However, once you have grouped the data (this is done initially in fl-add, or retroactively using fl-edit or spreadsheets), the selection set prompted through the Fl-move command enables you to move the grouped data together. This function allows you to 'peel' off the data pairs on screen and place them where it is aesthetically pleasing.

The Group functionality is accomplished by grouping rows in the database that contain the related observations. You can group rows in a table by creating a column that contains the name of the group (where A is the name given to the first set of grouped data, and B, the second, and so on. In this case groups A and B represent linked foliations and lineations).

Creating group capabilities is a two step process:

1. Create a column for the grouping name
   - Choose **Fl-setup>Table Setup** and (in this case) select the **STRUC** table.
   - Click the **Column** radio button.
   - To create a new column, click **New**, then input the name (**grp**).
   - Now **Save**. Move the column using the **Move** command so that it's below the dip column
2. Register the table.
   - Click the **Table** radio button, then **Setup**. You'll be in the table registration screen.
   - The **Group Number** (bottom right of screen) is now active — click the button and type in the group column name (**grp**).
   - Click **Register**. Be sure to save your fl-setup.

After entering data that includes group values, the end results look like this:

Station#	Feature	strike	dip	grp
1	foliation	200	20	A
1	foliation	145	35	A
1	foliation	330	60	B
1	foliation	350	48	B

NOTE: Don't use **GROUP** as a column name. It's a RESERVED word in AutoCAD R13/14 sql language. If you use it you won't be able to access your database and will have to change the column title using an external database.

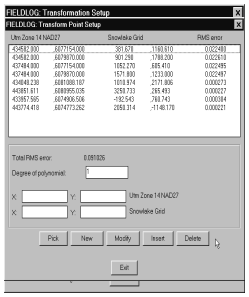
If you are adding grouped columns and grouping your data retroactively, you need to use ***fl-update*** on the entities on the map, or replot them from a query.

Map Setup

Map Setup assigns a projection to the AutoCAD map, permitting FieldLog to associate the map with an actual location on the earth's surface. Map Setup also controls the default display preferences for the plotting of symbols and text onto the AutoCAD map. It doesn't affect the actual data in the database — it simply controls defaults on the current projection system

Transformation Setup

In order to *transform* coordinates between user defined coordinate grids and standard projections (e.g., converting between the SnowLake user grid and UTM) you need to define a *transformation* using **fl-setup > transformation> setup**. To define a new transformation, provide a name and the source and target projections. Then, in the *Points* dialog, input paired reference points from both projections. FieldLog calculates a function for the conversion and lists the amount of error at each point.



Symbol Scale Note

Even though FieldLog plots symbols as either blocks or shapes, every symbol must originate from an AutoCAD shape library. FieldLog provides tools to ease the construction of these libraries. See Appendix A.

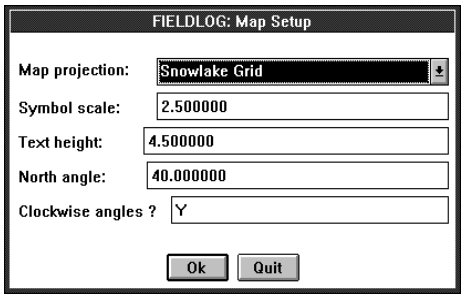
Suggested symbol and text sizes:

scale	symbol size	text size
1:20,000	12	25
1:50,000	40	80
1:250,000	200	400

and symbol display. Whenever you start using a new map with an existing FieldLog database project you **MUST** perform map setup. The map setup preferences are actually embedded in the map and saved with the map when you perform an AutoCAD save (e.g., **File>Save**). Thus map setup need only be performed a single time for each map, and once the map is saved those preferences are activated each time the map is used with FieldLog. Of course, to change Map Setup preferences, the map must be saved for the changes to take effect in future sessions.

1. To access map setup, click **Map Setup** in the FieldLog Setup button box.

   The Map Setup dialog box appears.



Note that although these values pertain only to the current map associated with a FieldLog database, they are all required for FieldLog to function.

Projection — before using a map with FieldLog you must assign a working projection to the map. This projection relates points on the map to actual locations on the earth's surface. It also permits seamless conversion between points in the database and the map, when the database and map coordinate systems differ. FieldLog won't be able to perform any operations on the map until a projection is specified in Map Setup.

Often in field mapping some of the data being added to a database is purely graphical in nature, such as road locations, grid lines, and lakes. The **Map Projection** pop-up allows you to specify the projection for this graphical data, so that any field data in the associated FieldLog database can be correctly located and plotted to the map during Fl-Add, Fl-Query, and so on. The actual FieldLog database may store coordinates in a coordinate system other than the map's, and as long both are clearly specified the FieldLog engine converts between them whenever required. Database coordinate systems are specified using the **Points** button in **fl-setup>Table Setup**, as described above.

Symbol scale — This is the default size scale factor for map symbols. AutoCAD draws symbols using *blocks* or *shapes*, which are objects composed of a group of lines and curves amalgamated into a complex shape. The size of these *blocks* or *shapes* is specified at the time of creation, in drawing units. Since drawing units differ dramatically in size depending on map projection, and since map scales vary dramatically in scale depending on geological purpose, you usually have to scale symbols up or down to suit the map currently in use.

For example, the symbol libraries that come with FieldLog (*OGS.SHX*, *GSC.SHC*, and *NATMAP.SHX*) contain symbols drawn at 10 units in length. Specifying a *Symbol Scale* of 2 would double all subsequently drawn symbols to 20 map units in length.

Note that this default *Symbol Scale* can be overridden for individual columns or elements of a symbol dictionary using the **Palette** button in **fl-setup>Table Setup**, **fl-add** or **fl-query**.

Text height — Default height for text in current drawing units. Unlike *Symbol Scale*, which magnifies or diminishes symbols, *Text Height* sets the actual size of text drawn to the map.

As with *Symbol Scale*, map projection differences mean that the needed height for text must be established visually, based on a combination of map scale and projection. In practical terms, annotation text should be about 5-10 mm high on the final, printed map. Since map scales for output often vary dramatically, the default text height value can be overridden with the **Palette** button, available in **fl-setup>Table Setup**, **fl-add**, or **fl-query**.

North angle — The angle from 'right' on the map, measured counter-clockwise, which represents North or 0 degrees. This value is used to correct the rotation of structural symbols to take into account rotated map projections and user grids. Valid responses are 0 - 360. For a 'normal' map, where north is to the top of the page, the value would be 90. Because a user grid was superimposed on the SnowLake map, its North angle is actually about 50 degrees from the 'right'.

Clockwise angles — Enter 'Y' for azimuthal angle measurements, or 'N' for standard Cartesian counter-clockwise method. In order to plot oriented data measured using standard azimuthal techniques (i.e. strike, dip direction) this parameter must be set to 'Y'.

You can experiment with the symbol size and text height parameters as you use a map. For example, the size of symbols and text already present on a map may be modified using the fl-scale command. Experimenting with north angles is more problematic (and shouldn't be necessary). If the angle values are wrong, any plotted symbols are incorrectly rotated, and you must either carefully erase these and replot after correcting the north angle value; or preferably, apply the fl-update command to the plotted symbols and their angles are corrected after correcting the north angle value.

Fl-Update

You may want to update your map to reflect changes made to your database (for example, replace old symbols with symbols from a new library or reposition FieldLog entities after transforming database coordinates). This can be easily done using the **fl-update** command.

1. In AutoCAD, turn off all the layers except for layers containing the FieldLog data you want to update.
2. Select **fl-update** from the FieldLog menu. Your cursor returns to the screen, waiting for entity selection. Select some entities to update and press **Enter**. FieldLog updates all of the selected entities, replacing old symbols with new ones or repositioning entities in new locations. Remember that you can use the 'w' option to window an area instead of manually selecting entities.
3. **Save** your map in AutoCAD.

Conclusions

FieldLog customization is essential when adapting an existing project setup to suit the needs of a new field mapping area. It is almost always easier to modify an existing project than to create a new one from scratch. The empty version of the *SnowLake* database, *SnowEmp*, is included with the FieldLog distribution as a template for building new projects. It contains the SnowLake data structure, all dictionaries and profiles, as well as all input and display preferences from the SnowLake sample project. Only the actual data has been removed.

Finally, remember that carelessly done table modifications cause big problems! Always back up a database and associated drawings before modifying the setup, and test the new setup thoroughly.

CHAPTER 8

Importing and Exporting Data; Using the Newton, GPS, and External Databases

Introduction

FieldLog is a rudimentary GIS that stores and manipulates geological field information. One of its strengths lies in its interface capabilities, which range from importing field data from hand held computers or various database systems and text editors, to exporting data to advanced GIS tools such as ArcInfo and MapInfo.

In this chapter, we focus on capturing and storing measurements and observations collected on an outcrop using the Apple Newton and GPS. We also discuss importing this data into FieldLog, and describe how to export the data in a variety of formats.

Working with FieldLog and the Newton

Many hand-held computers can record field data (including GPS information) about outcrops in a format you can easily and seamlessly download into a PC FieldLog database, and subsequently plot to an AutoCAD map. The Apple Newton, coupled with Fieldworker Pro software, is one of the hand-held systems that has been used extensively with FieldLog.

Geologists collect data in the field using the Newton and a GPS, download the data at the field camp onto their PC as a text file, and then append the data to their FieldLog Project database. The new data is then plotted, providing an up-to-date map that can be printed to scale using portable printers. Other geological features, such as contacts or structures, can be added to the hardcopy map or directly on the digital map as the field season progresses.

Why the Apple Newton?

About the Newton

There are several Newton models: the 120, 130, 2000 and 2100. The 2100 offers increased speed and memory capabilities: the 130 has 1 MB of memory, while the 2100 has 4 MB, and is four times faster. Because Apple stopped producing the Newton in March 1998, you can only buy second hand Newtons, available from third-party retailers. Non-Newton handhelds are being used with various degrees of success.

Despite its demise, the Apple Newton is still the hand-held system most actively used with FieldLog. It has a powerful pen-based operating system (OS) with hand-writing recognition and a touch sensitive screen, making it invaluable when inputting data into a field database. The Newton also supports a GPS interface, many other external connections, and has proven itself in the field. The effectiveness of its Windows CE successors is unknown at this time. However, because the import/export capabilities relevant to this chapter are software specific, and not hardware dependent, much of the following discussion also applies to non-Newton hand-helds.

Why Fieldworker Pro?

Newton Accessories

The Newton 2000 and 2100 come with a cable and a connection adapter (for GPS, up/downloading, printing, and so on). The adapter is fragile as it protrudes from the Newton when plugged in. You can protect it by securing it to the Newton using duct tape. Or you can use a serial card for external connectivity (use an 8 to 16 MB card to allow for backups). Newtons use 2 double AA batteries, good for about 2 days of field work.

Fieldworker Pro (FWPro) is commercial software (www.fieldworker.com) that turns the Apple Newton into a geological data entry device; in many cases it has replaced the traditional field notebook. Fieldworker allows data entry screens to be configured by the user and subsequently used for site-based data entry. It also receives and records GPS information. Geologists can still use airphotos and topographic maps to visually locate themselves in the field, but will need to digitally capture the locations into their FieldLog database using a digitizing tablet.

There are now several versions of Fieldworker, including some (2.0 to 2.3) that don't suit geological data. Fieldworker Pro is very flexible and geologically useful. It permits segregation of observation types at a station and then permits multiple occurrences of that type to be recorded - in other words, it's fully relational. For example, multiple lithologies, structural measurements, photographs, and samples can be recorded at a site.

When used in conjunction with FieldLog, the Fieldworker Pro setup must be identical to your FieldLog database design. You can do this easily by generating the FWPro data input template directly from FieldLog (as discussed below). Although FWPro allows you to build data entry templates interactively, to maintain correspondence between FieldLog and FwPro database designs, you should make changes in FieldLog and transfer them to FWPro. FieldLog also has advanced design features unavailable from the FWPro setup process. Because FWPro reflects your FieldLog database design, carefully consider your FieldLog design to facilitate its transfer to FWPro and to optimize the field data recording process.

What You Need

- Newton Connection Utilities (NCU): These utilities allow you to install software such as Fieldworker Pro onto the Newton. They also allow you to connect the Newton to your PC.
- Fieldworker Connect (FWC): This software is used primarily to transfer the FieldLog project template to the Newton and to transfer field data from the Newton to your PC.

Before You Start

- Ensure that you have installed FWPro, NWC and FWC on your PC

- Ensure your Newton is connected to your PC
- If you haven't used the Newton or FWPro before, do the Newton setup/ tutorial, complete the handwriting recognition exercises, and read the FWPro manual for background information.

Loading Fieldworker Pro (FWPro) on the Newton

Backing Up Your Data

Although transferring data from the Newton to your PC is relatively easy, errors do occur. For example, you may accidentally overwrite data instead of appending it. As a result, keep labelled disks with daily backups. Remember, back up your map as well as your database.

To load FWPro onto the Newton:

1. On your PC, open the Norton Connection Utilities (NCU).
   - From the horizontal menu bar, select the Newton pull down menu and choose **Settings**.
   - In *Port to Listen On*, select the com port dedicated to your Newton.
   - In *Speed*, select **9600** for the Newton 2100 or **2400** for the Newton 130.
   - Click **OK**.
2. On your Newton, click the **Dock** icon.
   - Click ♦ **connect** and change the settings to match those on your PC (for example, serial 9600).
   - On the bottom right of the Dock screen, click **Connect**.

The Connection status line should now say *Connecting to Newton device...using Com port 1*. You can watch the progress of the installation by viewing the time bar on either your PC or Newton. When the installation is done, close down the NCU on your PC. To verify that FWPro is installed on your Newton, tap ***EXTRAS***. FWPro should now reside under ♦ **unfiled** icons.

Creating a Project Template to Use with FWPro

FWPro data entry forms (i.e., the project template) can be generated by FieldLog or you can create them manually in FWPro. To maintain correspondence between your FieldLog and FWPro databases, and to take advantage of advanced project setup features that are automatically generated by FieldLog, use FieldLog to create the project template.

Terminology: FWPro vs. FieldLog

FieldLog uses ***column*** and ***table*** in its project database setup vocabulary, whereas FWPro uses the words ***field*** and ***screen*** respectively. The word ***screen*** can also refer to the Newton screen (i.e. *tap on the screen*) in the FWPro or Newton manuals.

Before you generate a project template from FieldLog, make sure the order of the columns in each table reflects your mapping style. Because FWPro displays the columns in a vertical list on the Newton, you will save time in the field if you arrange these columns according to your preferred data recording sequence. FWPro does **not** allow the order of the columns to be changed; furthermore, doing so would compromise the similarity between the FWPro and FieldLog databases.

Making a FWPro Project Template from FieldLog

To make a FWPro project template from FieldLog:

1. Ensure you are logged on to a FieldLog project.
2. In FieldLog, choose **fl-setup>Save External Setup**.
3. Click the **Fieldworker 2.0/2.3/Pro** button, then click **OK**.
4. Click the **Fieldworker Pro** button, then click **OK**.

The message *FieldLog setup saved* appears.

5. Click **OK**.

   The FWPro project template is saved in a file named *project.txt* in your project directory (*c:\snowlake\project.txt* for the SnowLake database).

WARNING: If you have data stored on your Newton, and you import a new project template into FWPro, you will lose all stored data. To alter your FWPro setup without losing stored data, you must use FWPro's setup capabilities (see the FWPro manual). **Any changes in your FWPro project setup MUST be exactly replicated in your FieldLog project setup BEFORE importing the FWPro data;** failure to do so will result in FieldLog data import errors. FWPro is limited in the types of changes that can be made interactively.

FWPro's setup capabilities/restrictions include:

- The addition of columns, tables and pick-lists is allowed; shifting the order of tables, columns and pick-list terms isn't allowed
- New tables can possess a maximum of 7 fields (however, your project setup on the Newton will reflect your FieldLog database, regardless of how many columns are in the table)
- Only tables that occur once per station (e.g., STATI in SnowLake) can be created via interactive FWPro setup

Transferring a FWPro Project Template from the PC to the Newton

To transfer a FWPro project template from the PC to the Newton:

1. Ensure your PC and Newton are connected with a serial cable
2. On your PC
   - Open *Fieldworker Connect (FWC)*.
   - To display the transfer options, click **Show**.
   - To enable editing of the default settings, click **Unlock**.
   - Ensure that the transfer arrow reflects the operation you want to perform (i.e. transferring from PC-->Newton). If necessary, click **Reverse** to change the direction of data transfer to reflect PC-->Newton.
   - Specify the *Newton* (*HPC*) transfer options:
     - port: select the *com port* connected to your Newton
     - speed: select the *baud rate* to reflect the model of Newton used (e.g., Newton 130=*2400 baud*, Newton 2100=*9600 baud*)
     - control: select a flow control to regulate the data transfer (e.g., *hardware*)
   - Specify the *PC* (*Desktop*) transfer options:
     - directory: specify the directory containing the project template (e.g., *c:\SnowLake* for the SnowLake project)
     - multiple users: ignore
     - split: ignore
     - allow filesearch: ignore
     - send: *project*; data or projects may be uploaded to FWPro

- Specify a filename (in the edit box beside *Open*) for the configuration (the configuration can be recalled afterwards by *opening* the filename).
- To save the configuration, click **Save**.

3. On your Newton:
   - Choose **Extras>Unfiled Icons**, then select **FWPro**.
   - At the top left corner, select **♦Project**, then **Import**.
   - Change the information in the *Options box* to reflect the settings from the PC.
4. On your PC:
   - Click **Transfer**.
   - Select your project template file (i.e. *project.txt*).
   - Click **Open**.

     FWC responds with *Tap Import on you HPC now.* Don't click OK in this message box yet.

     Note: You **MUST** tap the import button on the Newton **AFTER** you have begun the transfer on your PC, but before you click **OK** to this message. If you tap the Newton's Import button too early, cancel, then re-tap it before you click **OK**.
5. On your Newton:
   - Tap **Import**.

     The Newton status line displays *Newton ready to receive data*.
6. On your PC:
   - In response to the *Tap Import on your HPC now* message, click **OK**.

You should see your project tables displayed on your Newton as they are loaded. When the transfer is finished, the status line displays *Transfer is complete.* Verify in FWPro that your project setup information was transferred correctly by going into the tables and checking that all of your fields are present. Pay particular attention to the last table.

Problem Solving: Other Alternatives

FWPro has excellent troubleshooting. Their manual is a good place to start. Their web site also has an informative FAQ dealing with transfer problems. If all else fails, contact FWPro and they will try and advise you.

FWPro Import Project Notes

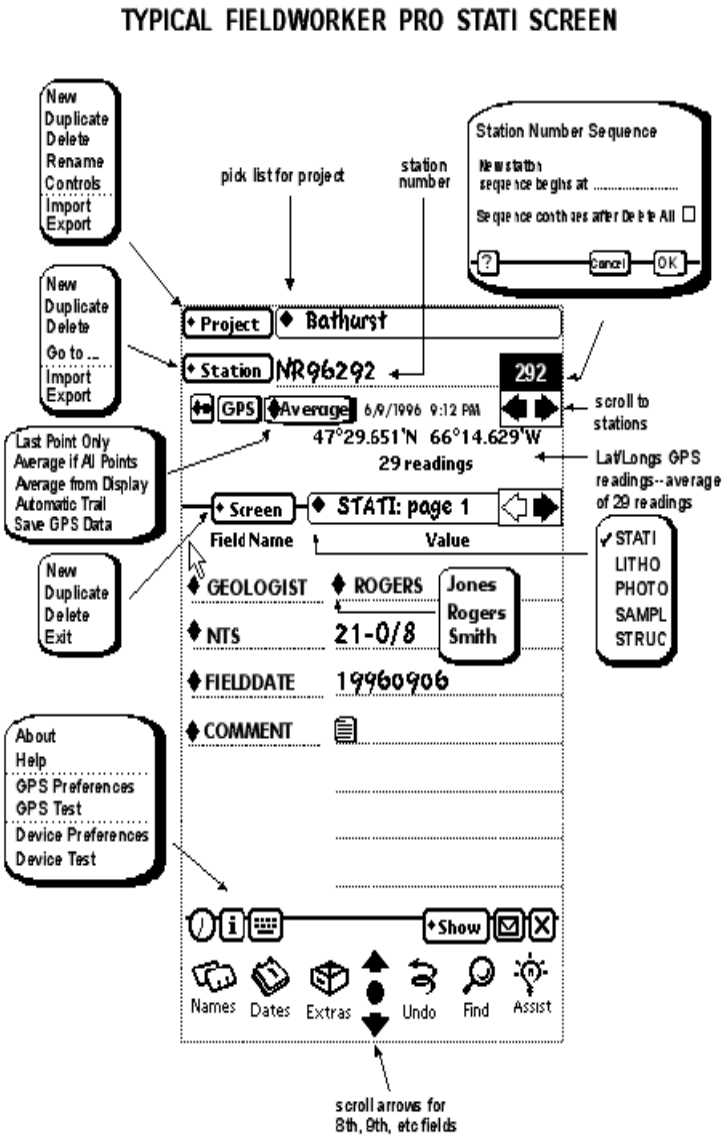
Large project setup files, with many pick lists, can exceed the Newton's memory capacity and cause projects to only load partially. To overcome this, eliminate or shorten some of the pick lists.

Troubleshooting

If the tables don't load properly, try the following:

- Repeat the transfer (without making any changes)
- Check to make sure the Newton transfer settings match your PC settings and that you have the proper com port dedicated to your Newton
- Repeat the transfer, using a lower baud rate in the transfer settings
- Use a text editor to open up the.txt file and check the syntax against the examples in the FWPro manual (you may be missing an EOF statement)

Note: If you are using the Newton 2100, and your transfer fails, you may need to hit the reset button. Otherwise, each subsequent transfer attempt may fail, even if you have solved the initial problem.



Data Input on Site Using the Newton, FWPro, and GPS

The Newton and FWPro

Your project template should now be loaded onto your Newton, and FWPro should be ready to accept input data. Prior to entering data, remember that FWPro refers to FieldLog tables as *screens*, and to columns as *fields*.

To enter data, activate your Newton, and open FWPro by selecting the *Fieldworker Pro* icon located in the EXTRAs bin. Select your project name from the pull down menu at top left hand corner of the screen. FWPro defaults to the STATI screen when a project is first opened.

If you are using GPS, turn it on as soon as you arrive at your new/next station, as positioning and averaging of the location point data takes a few minutes. FWPro lets you input other station data (i.e. structural measurements, lithological observations) while processing the location information in the background. When the GPS has finished calculating the location coordinates, the information appears on your STATI table screen near the top of the display.

1. Fill out the STATI screen. Click on black diamonds to the right of the field name to access picklists. If the *screen* has more than 6 data entry fields, black vertical scroll arrows located in the centre of the screen, just below the 6th field, become active, allowing you to scroll down to the 7th or 8th field. To get to the next screen, either click the black diamond to the left of STATI, or click one of the horizontal scroll arrows to the right of the STATI screen.
2. Fill out all the screens for that station the same way you would add data to the FieldLog database using *Fl-add*.
3. Make sure that you have received the GPS information for the station before moving on to the next station.

GPS Techniques

There are basically 3 different GPS methods — real-time selective availability (SA), differential correction using post-processing methods, and real-time differential correction using FM radio broadcasts. The choice of one system over another requires a cost/benefit analysis.

Ideally you want real-time points captured in the field and corrected on-site using FM broadcasting. However, in remote areas, broadcasters are typically out of range, (except for coastal areas, where the coast guard is able to provide the service). In addition, these GPS units tend to be more expensive than GPS for selective availability systems.

Post-processing requires a base station and an expensive GPS. The GPS locations are kept on the GPS (rather than on the Newton), then processed. Finally the two data sets are combined in a database such as FieldLog or in a spreadsheet.

Note that S.A. has been turned off recently, resulting in more accurate basic readings. Post-processing and real-time corrections may still be required for very high precision locations.

Global Positional Systems (GPS)

What is GPS?

Global Positioning System (GPS) is based on a field receiver getting signals from satellites located high (~ 17,600 km) above the earth in a stable orbit. The travel time of each signal transmitted by a satellite and received by the GPS receiver is computed and your location on the earth's surface is then calculated by triangulation. Signals from at least 3 of the 24 orbiting satellites are required for an accurate location, signals from a 4th satellite allow your receiver to resolve altitude information. Importantly, since May 2000, the U.S. Government has removed intentional scrambling of the GPS signals (they were originally scrambled to prevent other governments from using the data to guide missiles). This means you now get very accurate readings.

Why Use GPS?

The use of GPS with FieldLog remains optional. GPS technology has changed dramatically over the past few years — lower prices, improved accuracy, and quicker positioning speeds make it a viable alternative to traditional data location methods. There also appears to be a direct correlation between field mapping areas and systems used. It seems that where the geology is well exposed, the geologist is getting into high-precision GPS and related gadgetry (for example, laser glasses which transmit digital images and vectors directly to a computer). A large emphasis is placed on immediate cartography and 3d visualization and the technique

GPS Equipment

You need an adapter or serial card to connect the GPS to the Newton. This is the same adapter used to connect the Newton to the PC. GPS units become more expensive as they increase in reception speed and accuracy (e.g. centimetre accuracy) — these typically possess a stronger receiver as well as more channels for receiving satellite information.

of choice appears to be post-processing. Where the geology is less exposed, a greater emphasis is placed on the actual field observations and notes, and the data collected is generally point data. A field mapping style of predominantly regional mapping of moderate to poorly exposed rock generally places users into the latter category where real-time selective availability system (SA) is used — GPS readings are funnelled directly to the Newton on the outcrop without intermediary processing, but with reduced accuracy and resolution. Since SA scrambling was stopped, this translates to ~10m accuracy, more than adequate for regional mapping.

For regional scale mapping of 1:50 000 to 1:250 000, the SA accuracy of 30-100 metres is usually acceptable. Fieldworker also does some on-site averaging, which helps increase the level of accuracy. Even at 1:50 000, this represents 0.5-2mm accuracy — the same level of accuracy achieved when using traditional methods of airphotos and topographical maps for positioning.

The GPS data downloads to the FieldLog database via FWPro and the Newton. This method of positioning not only eliminates the tedious and lengthy task of calibrating the tablet and digitizing station locations, it also eliminates errors introduced while digitizing and calibrating. FWPro also allows tracing of macroscopic linear features (faults, dykes and contacts) using a GPS. However, unless some modifications are made in your project database template, FWPro treats these linear features as station point data.

Solar Flares and GPS

Solar flares sometimes affect GPS. However, flares severe enough to affect GPS and communications are rare, usually forecasted, and warnings are issued. There is a “solar activity” number you may want to check periodically:

303-497-3235

A significant downside of GPS is that there are times when satellite orbits, obstructions, and weather combine to make it impossible to get a fix from 3 satellites. For more information, consult a reference on GPS.

Before You Begin

Ensure you have the appropriate cable and adapter for GPS-Newton connection. Label which end of the cable goes into which apparatus. Make sure both your Newton and GPS have active batteries. Carry a backup set of 4 batteries.

Your GPS unit should be accompanied by a straight-forward manual that describes how to navigate its menus using arrow keys, guides you through your setup, and instructs how to get readings for your current location. The life span of GPS batteries is ~ 6 to10 hours for alkaline batteries and 12 to 20 hours for lithium batteries. Often GPS report the actual total time in use. Typically, each time you remove your batteries from the GPS powerpack, you have to reset the defaults.

What is NMEA?

If you are using a GPS you will undoubtedly come across the terms NMEA or NMEA 0183. In 1983, the National Marine Electronics Association (USA) developed a voluntary standard for Interfacing Marine Electronics Devices — NMEA 0183. This Standard defines signal requirements, data transmission protocol, timing, and specific sentence formats for a 4800 baud serial data connection. The standard has been periodically updated. For more information on NMEA go to www4.coastalnet. com/nmea

Default GPS Settings

To transfer location data from a GPS unit to the Newton, the *baud*, *connection*, and *collection* settings of the GPS unit must match the GPS settings of the Newton. These settings are located under **Setup** on the GPS unit (refer to your GPS manual) and under on the Newton **Extras>FWPro>i** (information icon, near bottom left of screen)**>GPS Preferences**. You also have to choose the appropriate settings from picklists for **Receiver Accuracy**, units, Coordinate type **(Grid** and **Display)**, and **Datum Conversion**, all of which are on your Newton GPS Preferences screen.

Your Newton GPS preference screen includes:

Receiver Accuracy ♦ 100 ♦ **Metres** (toggle between ft. & m.)
(pull down picklist with preset values)

Connect ♦ Serial ♦ 9600 **baud**

Collect ♦ GGA*

Display ♦ Grid
(pull down picklist with preset values)

Datum Conversion (choose from picklist below)

Select ♦ Last Point Only

Average of All Points

Average from Display

Automatic Trail

Save GPS Data

***Note:** There are at least a dozen different types of 'protocol' or, in GPS terminology, *Sentences*, used when collecting GPS data. The most common sentence is (GP)GGA — GPS Fixed Data. See your GPS reference manual or a GPS text for more information.

Datum Conversion

The most commonly used method for datum conversion is *Average from Display.* With this method, you can view all readings as a scatter diagram, allowing you to eliminate outliers before the average is calculated. *Average of All Points* is calculated from all GPS points collected at the field location. For both *Average* options, field observation data can be input while the location readings are being calculated in the background. Use *Last Point* when you are confident that the current reading is accurate enough to use. The last coordinate read is retained, and no averaging is performed. You can select these options through ♦ **Display**, which is located on your station screen, beside the GPS button. FWPro manual describes the process of capturing location data.

Collecting GPS Data

Turn on the GPS as soon as you reach your station as the GPS can take 10 minutes or more to track the 3 satellites needed for triangulation. A status line on your GPS display tells you how many satellites it has found. The GPS can also function independently, without plugging into the Newton, allowing you to move about the area making observations and entering measurements. When you have finished entering data, simply plug the GPS unit into the Newton. You may still have to wait for a final satellite transmission, or for FWPro to average your data. When the GPS has finished calculating the location coordinates, the information appears on your STATI table screen near the top of the display. You should see something like this:

15 485,072 -41.1 M

7,071,888 4 satellites

where the 2 digit number in this case (*15*) refers to the UTM zone, the 6 digit number (*485,072*) is the UTM Easting, and the 7 digit number (*7,071,888*) is

the UTM Northing (if UTM meters are selected in the FWPro's GPS Preferences>Display option; otherwise a lat/long is reported). *-41.1 M* refers to elevation in Metres above sea level, and *4* satellites were used to triangulate.

Transferring Field Data from FWPro to FieldLog and AutoCAD

Converting .gif Files

Converting .gif files to .bmp or .tif formats involves using a third party image conversion software package such as Corel PHOTOPAINT or Adobe. Simply open the .gif file and save it as a .bmp or .tif file.

Once you have collected your observations and measurements, you need to transfer this information to your FieldLog database and update both the database and possibly your map. **This is a 3 step process**:

1. Export your FWPro field data to a PC (as a text file) using FWC.
2. Import the field data text file to a FieldLog database.
3. Plot the results to the AutoCAD map by querying the updated FieldLog database.

After transferring your data from the Newton to your PC, you must also add to your database any information that is not station specific and was therefore not included in data entry on the Newton. This includes traverse, legend, and geological unit information.

If you made sketches on the Newton, you must also transform your sketches into a format compatible with AutoCAD. FWPro exports sketches as .gifs, which AutoCAD can't import. You can convert .gifs into either .bmp or .dxf formats using a utility program.

The detailed steps to bring FWPro data from a Newton to a PC follow.

Create an Export Text File on the Newton

1. On the *Newton*, select your current project
2. Click **Station ♦**, then select **Export**
3. Input the station values at the *From* and *To* station prompts
4. Use the following settings for the rest of the screen:

   ♦ Data: *All excluding sketches* or *All including sketches*

   Note: Sketches significantly increase the download time and also require re-formatting from .gif to AutoCAD/FieldLog compatible formats (.bmp, .wmf, and so on).

   6 GPS Format: *Fieldworker*:

   ♦ Delimited by: *Tab* ☑ Field Names

   ♦ Many tables include: *Station name*

   ♦ Connection at: *9600* ♦ To: *DOS*

   ♦ Flow Control: *None* ♦ via: *Serial*

This finishes the export on the Newton.

Transfer the Export File from the Newton to the PC using FWC

After completing the *Newton>Export* screen, you're ready to transfer the file to your PC.

On your PC:

1. Open *Fieldworker Connect (FWC).*
2. To change your default settings, click **Unlock**.
3. Make sure that the transfer arrows reflect the operation you want to perform (i.e. transferring from PC to Newton or vice versa). If necessary, click **Reverse** to change the direction of data transfer. The screens look different for each direction of file transfer.
4. Fill out the fields. Select the *Com port* dedicated to the Newton and the *Baud rate* that reflects the model of Newton you're using. The default fields in the lower right side should look like this:
   - ***Directory***: specifies the directory that receives the data.
   - ***Multiple users***: places files from different Newtons in separate directories (one for each user). Use this when users have different FieldLog databases.
   - ***Split***: creates (or appends to) separate files for each screen (table) type. This is required by FieldLog, which can only import tables individually. The filename of the text file inherits the FWPro screen name with a .dat extension (e.g., Lith.dat). You can allow users to supply alternate file names by activating the ***Ask for file names*** option discussed below. FWC also creates some .txt files for its internal use.
   - ***New Directories***: when this option is selected and the directory specified above doesn't exist or if directories for multiple users don't exist, FWC creates them; otherwise the transfer fails.
   - ***Ask for file names***: prompts the user for filenames when creating new files for the downloaded data. This allows users to name files instead of using default file names (e.g., 'struc.dat').
   - ***Append*****:** determines whether a new data file is created for incoming data (and the old one overwritten) or whether the incoming data is added to an existing data file. This is particularly useful when multiple users are downloading data daily, as it combines their observations into one set of text files that can then be imported into FieldLog as a single set.
5. Specify a filename (in the edit box beside *Open*) for the configuration (the configuration can be recalled afterwards by *opening* the filename).
6. To save the configuration, click **Save**.
7. Click **Transfer**.

   The Newton status line informs you what table is being transferred. The PC status line shows how many bytes of data have been transferred to your PC.
8. When the transfer is finished, a *Transfer is complete* message appears. Click **OK**.

Transfer the Data File to Your FieldLog Database

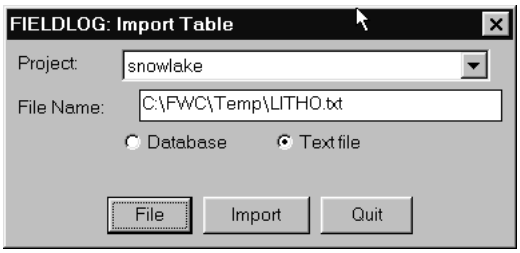
After transferring data from the Newton, your data directory contains .dat data files and .txt setup files. It's good practice to review the downloaded .dat files prior to importing them into FieldLog. You can use any word processing software for this. If you change the.dat files, you **MUST** save them as plain text files. Failure to do so prevents them from being successfully imported into the FieldLog database (most word processors add

hidden codes to files as they are saved which interfere with FieldLog data import).

Note: Only tables that contain data get transferred. Empty tables are ignored.

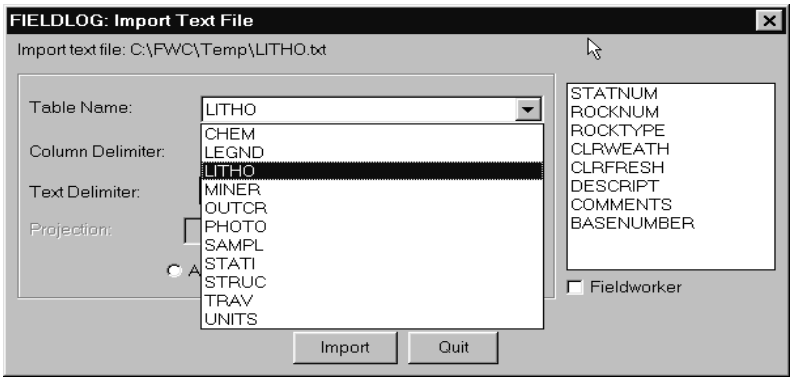
To transfer the newly acquired data to your FieldLog database:

1. Open **AutoCAD>FieldLog**. Logon to your project (in this case SnowLake).
2. Choose **fl-import**.
3. To locate your file, click **File**. Enter (or select) the file name in the File Name box
4. Click the **Text file** radio button.



5. Click **Import**.

   The FieldLog: Import Text File dialog box appears.



6. Select the FieldLog table you want to append/update (in this case LITHO). The columns of the LITHO table appear in the right column of the screen.
7. Select all the columns, excluding BASENUMBER.
8. In the *Column Delimiter* box, type `tab`.
9. Leave the *Text Delimeter* box blank.
10. In the *Projection* box, scroll and enter the appropriate projection. This box is active only if you're importing data into a table that contains coordinates (e.g., in the Snowlake database, the projections are stored in the STATI table).
11. If you are importing into your main table (e.g., the STATI table):
    - Select the *Fieldworker* option

      The column on the right side of the screen becomes blank

    - Ensure that you have filled out your projection correctly.
12. If you are appending data, click **Append**. This adds the data from the text file to the database table. If you are overwriting existing data, then click **Update**. **Update** is selectively available, depending on the type of database table.

13. Click **Import.**

    FieldLog lists the number of rows imported along the bottom of the screen. If a row of data can't be imported, an error message appears, which must be cleared by clicking **OK** before the import process will resume. Rows that can't be imported are written to an .err error file beginning with the table name (e.g., LITHO.ERR). This file can be edited as necessary and re-imported as a text file.

Plot New Data to the Map by Querying FieldLog

Alternative Export Formats in AutoCAD

If you are exporting an AutoCAD map to CorelDRAW and your drawing doesn't require any more editing before printing, it may be useful to export as a Windows metafile (WMF) or an Encapsulated Postscript (EPS) file. These options are available in AutoCAD under the **File> Export> Save as file type** list. The advantage of using .wmf and .eps is that the FieldLog symbols will come across to CorelDRAW regardless of whether they are shapes or blocks. When you save as .wmf, you are returned to your drawing file and prompted for a selection set. When you save as .eps, it saves the entire file on screen as a screen dump or print file.

It is often advantageous to immediately visualize imported data, particularly in collaborative and multi-disciplinary mapping situations. If you have downloaded data from the Newton, you must plot the new data to the map on a table by table basis. This requires a separate query/plot operation for each imported file/table. Since you can name queries in FieldLog, this is not as arduous as it sounds. You simply need to modify a standard query.

In FieldLog:

1. Choose **fl-query**.
2. Starting with the *STATI* table:
   - In the condition box, specify the station range you just transferred (e.g., *stati.stanum > 52 AND stat.stanum < 252*).
   - Name this query using a name that reflects the range (e.g., st53-252).
   - In the *Output* box, select: *stati.statnum, stati.utmx, stati.utmy, stati.utmz,* and *stati.statype*.
   - Run the query.
   - Plot the statnum and the column which contains the outcrop symbol, usually either *statype* or *statumx*, to the AutoCAD map.
3. Select another table (e.g., *LITHO*) and select the query name reflecting the range of stations you want to plot (in this case, st53-252).
   - In the *Output* box, select: *stati.statnum, stati.utmx, stati.utmy, stati.utmz, litho.statnum,* and *litho.rocktype.* Remember that you always need the UTM values when plotting to the map.
   - Run the query.
   - Plot any lithological information, usually *litho.rocktype*, that you want to display on the map.
4. Systematically go through your remaining tables and plot any data you want to display to the AutoCAD map by running a query — ensuring that you edit the query to reflect the data you want to plot. This permits you to plot all relevant data from the desired table. You can now edit the placement of information on your map for appearance. Do this using one of AutoCAD's move commands.

You must now add any information to your database that is not station specific, and was therefore not input on-site using FWPro. For example, the information pertaining to the *TRAV* table is not captured on the Newton. To add this:

1. Choose **fl-add**, then select the *TRAV* table.
2. Fill out traverses for all members of the field party.

3. When you have finished entering information in the *TRAV* table, select another non-station specific table you want to add information to.

Sketches

FWpro allows you to draw sketches and store them linked to a data entry field. Each sketch is uniquely named and this name becomes its filename (with a .gif extension) in the data directory when it's downloaded from the Newton. This name is also placed in the data file which is imported into FieldLog. Thus, in the FieldLog database, there will be columns, corresponding to sketch fields, which contain the filename of the sketch (e.g., in the STRUC table, there would be a column called sketch). You can display sketches in FieldLog by querying the database and displaying selected 'image' columns. You can also display sketches by plotting a symbol for the filename to the map and then retrieving the database record for that symbol (with **fl-edit**), selecting the image name column and clicking the **Image** button. However, before images can be viewed they must be converted from .gif format to .bmp or .tif formats, and the filenames in the FieldLog database must be changed accordingly.

Exporting Data from Your FieldLog Database

One of FieldLog's strengths is its interface capabilities. Data can be easily exported in a wide variety of formats compatible with other platforms. Export format options in FieldLog include: ArcINFO (E00), MapINFO (MIF), spans (TBA, VEC), and TXT files (for exporting to text editors, spread sheets, word processors, and most other data-oriented software).

In addition, many software packages can directly read FieldLog tables, since these are simply Dbase III format tables. If you do use FieldLog tables directly, make sure that the program you're using doesn't modify the table structure, as this would cause problems with FieldLog. The cartographic aspect of FieldLog data can also be exported as DXF (Digital Exchange Format) and many GIS packages directly read AutoCAD files. Lines (contacts, faults, and other macroscopic features) drawn using AutoCAD, as well as topographic bases, are generally exported using dxf format.

There are two methods for exporting FieldLog data — using **fl-export** and **fl-query**. Fl-export exports some basic AutoCAD entities, such as plines, shapes, blocks, and circles, and retains their cartographic appearance (e.g., size, angle, location, and so on) and related database information in the export file. Fl-export only exports data plotted to the AutoCAD map. You must export database data that's not on the map using fl-query. Fl-query exports data that has been selected via a query, even if it isn't plotted to a map. The four different export file formats (E00, MIF, TBA\VEC, and TXT) are available using either method.

The E00 file — an ESRI generated file format is used to import into ArcINFO and ArcView. Cartographers using ArcINFO to produce publication quality maps use E00 because they can easily import data — no data massaging is necessary. It maintains layer integrity and the point data records the location information as well as any rotational information of symbols. Database information may remain attached to the cartographic entities if the user chooses. Geologists export as E00

files because they can easily bring their E00 file into Arcview and view, manipulate, and analyse their data in conjunction with other data sets.

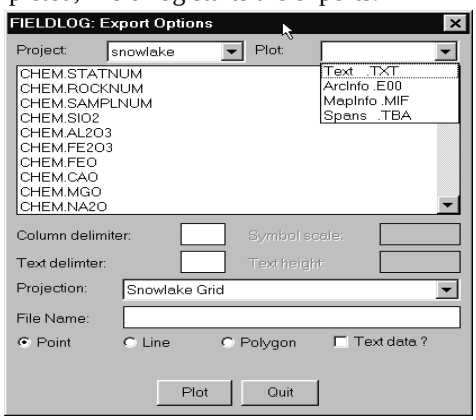
The MIF file — a MapInfo generated file is used to import into MapINFO. Like ArcInfo and Spans, MapInfo is a GIS that has strong data management, display and analysis functions.

The TBA/VEC file — a Spans generated file is used to import into Spans data analysis packages. Like ArcInfo and MapInfo, Spans is a GIS that has strong data management, display and analysis capabilities.

The TXT file — this format is extremely versatile and exportable to many different kinds of software packages — word processing, graphics, CAD, spreadsheets, and databases. For example, the FieldLog projection definition template is exported to FWPro in a special .txt format.

Exporting Data Using *Fl-export*

You must open your current AutoCAD drawing file before choosing **fl-export**. Once invoked, **fl-export** prompts you to create an export selection set by selecting entities from the screen. If your selection set covers a large area, you should turn off and lock all AutoCAD layers containing information that you don't want to export. You can use any of AutoCAD's common selection mechanisms to build a selection set (e.g., windowing an area to select its inhabitants). Once the selection set is built and selection completed, FieldLog starts the exports.



1. Choose **Fl-export** (from the AutoCAD menu or command line).
   - **Project**: select a FieldLog project from which to export database data. If no project is selected, only cartographic entities, with no attached database information, are exported.

- **Plot**: select the export format (i.e. TXT, E00, TBA MIF as discussed above). Notice that different export formats activate various export options; this is summarized in the table below.

File type	Data type	Input fields available	Common input values
TXT	all types	column delimiter text delimiter	comma double quote
E00	point	symbol scale text height	
	line	none	---
	polygon	none	---
MIF	point	column delimiter symbol scale text height	blank
	line	column delimiter	blank
	polygon	column delimiter	blank
TBA	point	column delimiter	blank
	line	none	---
	polygon	none	---

- **Database**: select the database columns that you want to export with each map entity. Note that a FieldLog map entity is associated with at most one row in one database table. Therefore, selecting columns from more than one table results in many empty fields despite there being data in the actual tables. It's best to select map entities and database columns from one table at a time. This means a separate export should take place for each database table.
- **Column delimiter**: is the character that separates columns in the export file. Typical column delimiters are commas, spaces, and tabs. For all delimiters except tabs only the actual character is typed into this field (e.g., , ; -). For tabs, the word **tab** must be typed.
- **Text delimiter**: is the character that encloses text columns. The double-quote (") is a common text delimiter. Note that if your database contains this character in data entries, significant problems will result.
- **Symbol scale**: is a scale factor applied to exported symbols. Leaving this field blank causes symbols to be exported at their current size.
- **Text height**: is the new text height. Leaving this field blank causes text to be exported at its current height on the map.
- **Projection**: selects the output coordinate system. FieldLog assumes the output coordinate system is that of the current map. If you want to project the map to another coordinate system (e.g., UTM to lat/long geographic) select an alternate projection from the list.
- **File name**: type a complete file name (e.g., *c:\SnowLake\structdata.E00*).
- **Spatial data type**: choose one of the three spatial data type buttons:

- **Point** for exporting symbols (i.e., shapes, blocks) and text. Select the **Text** option if you want to attach database information to text (e.g., when the only information being plotted from a table is a text field such as lithology or geologist names). Don't select the text option if the text is related to a symbol (e.g., structural symbol and dip), as database information would be generated in the export file for both the symbol and the text.
- **Line** for exporting plines.
- **Polygon** for exporting single-closed plines (i.e. polygons).

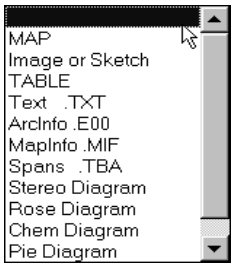
Note: If you want to export 3 different types of spatial data (point, line, polygon) then you must create three separate export files. Moreover, if you want to export database data with each map entity, then each table could need to be exported separately, requiring 3 (spatial data types) x N (database tables) export files.

2. Click **Plot.**
3. You are prompted to make your entity selection set. Select the entities to export from the screen, then press **Enter** to begin exporting. After completion, FieldLog reports the number of entities 'plotted' to the file.

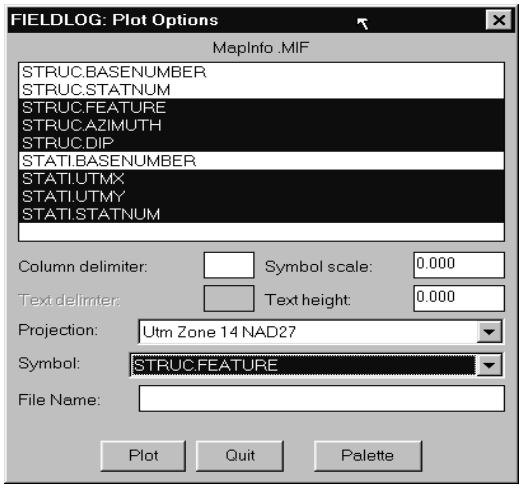
Exporting Data Using *Fl-query*

Fl-query generates an export file through the usual FieldLog fl-query process. However, instead of plotting your results to a map, you can plot them to an export file. Your data selection set won't be confined to your current drawing file, but can be any subset of your entire project database. Unlike fl-export, the fl-query export files are generated with cartographic defaults that can be modified. For information on performing FieldLog database queries, refer to Chapter 4.

1. Choose **fl-query**. Create a query that reflects the database subset you want to export. You must include an x,y coordinate in your query output to export the data to a spatial file format such as E00, MIF, TBA, or TXT.
2. At the FieldLog query Scroll Table dialog box, select your file export format from the *Plot To* pull down menu at the lower right corner of the screen.



3. Once you have selected your export file format, the Plot Options dialog box appears.



4. Fill out the plot options. Refer to the fl-export options above for more details on how to do this.
5. Click **Plot**.
6. FieldLog lists the entities being plotted. When finished, it displays the total number plotted in a message box.

Exporting Data Using Digital Exchange Format (DXF) in AutoCAD

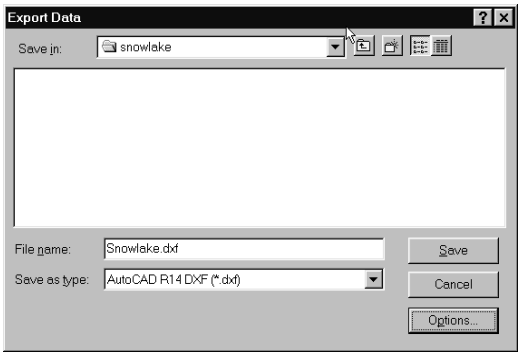
The DXF file is a widely used complex ascii file format accepted by several platforms/packages (ArcInfo, CorelDraw, MiniCAD, AutoCAD, to name a few). Each AutoCAD version is accompanied by an updated DXF version, and this causes some software packages to be incompatible with some DXF formats. For example, CorelDRAW 7 doesn't accept .dxf files from AutoCAD R14. It's also critical to realize that when exporting FieldLog data via DXF, non-AutoCAD products can't recognize database information associated with entities in the DXF file.

Shapes verses blocks. AutoCAD drawings that contain FieldLog symbols as AutoCAD *shape* entities often fail to be transferred via .dxf to other graphic packages (e.g., CorelDRAW). However, AutoCAD *block* entities are often successfully converted, which means you should change *shapes* to *blocks* in AutoCAD prior to DXF export. You can convert symbols to blocks at any time, but it's easier to do so at the start of a project (see appendix A for details about converting *shapes* to *blocks*). FieldLog's default symbol representation is the *shape*, but it can equally well use *blocks*. In either case, FieldLog must obtain the symbol definitions from one or more .shx symbol libraries. Alternatively, exporting via WMF (Windows Metafile) or EPS (Encapsulated Poscript) formats tends to preserve both symbol types (shapes or blocks), but may result in the loss of some other graphic characteristics (such as the recognition of a symbol as a single entity versus a series of unrelated lines) depending on the receiving software package.

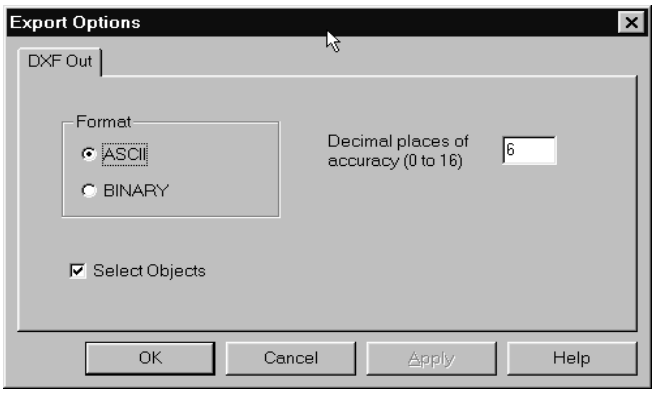
To create a .dxf file:

1. As ***dxfout*** is an AutoCAD command, you must have AutoCAD running with your current drawing file loaded. FieldLog doesn't need to be running.

2. If you're only exporting a few items, you can leave unwanted layers on and use the *selected* option. Otherwise, everything that isn't frozen or locked is exported, so turn off, freeze, and lock any layers that contain information not required for transfer.
3. Choose **File>Export**.
4. Choose the *.dxf* format in the *Save as file type* box.



5. Click **Options** if you want to export only *selected* entities, if you want to change the file format to binary, or if you want to change the level of accuracy (the number of decimal places exported in the ascii format). You can't set Options unless you have selected the .dxf format.



6. Save the file.

   You are returned to your drawing and prompted for your selection set. If you don't use the Options dialog box, saving the file causes everything not frozen or locked to be included in the .dxf file

Importing Database Tables and Text Files into FieldLog Databases

FieldLog imports external data via the fl-import command. FieldLog imports either database tables or text files, through its 'database' or 'text' options respectively.

When ***importing database tables***, the database table format must match the format of the FieldLog database. For example, if the FieldLog database is stored in dBase3 format (.dbf), then only dBase3 tables can be imported. Importing a database table involves insertion of a new table into your FieldLog database project. If, for example, you want to import a new

FieldLog database table CHRON containing geochronologic results called CHRON.dbf, you must use the 'database' import option. This option requires the table to be first identified from within your FieldLog directory, and then to be registered to a FieldLog project. Remember that FieldLog uses a rigorous data model. Certain fields need to be present in the table if it is to be registered to a project (see Chapter 7 for table registration).

Importing data as text files involves inserting new rows into pre-existing FieldLog tables or overwriting existing rows within these tables.

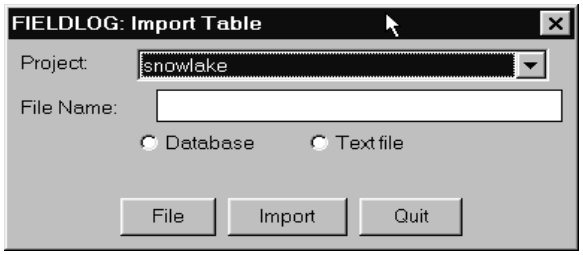
Note: Before importing any data into your database, make a backup.

Importing Data

Reserved Characters in Text File Import

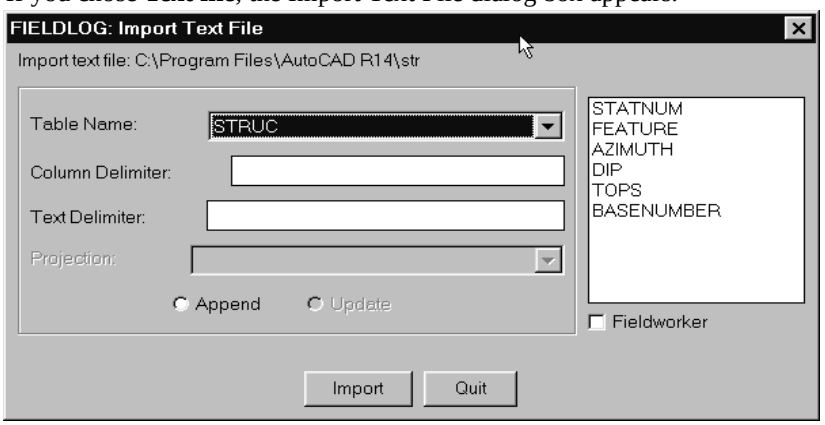
The single quote is a reserved character in SQL dependent databases. Its occurrence in text intended for import causes FieldLog to reject the row.

1. Choose **fl-import**.
2. Choose either the **Text file** or **Database** option.
3. To locate your file, click **File**.



4. Click **Import**.

   If you chose **Text file**, the Import Text File dialog box appears.



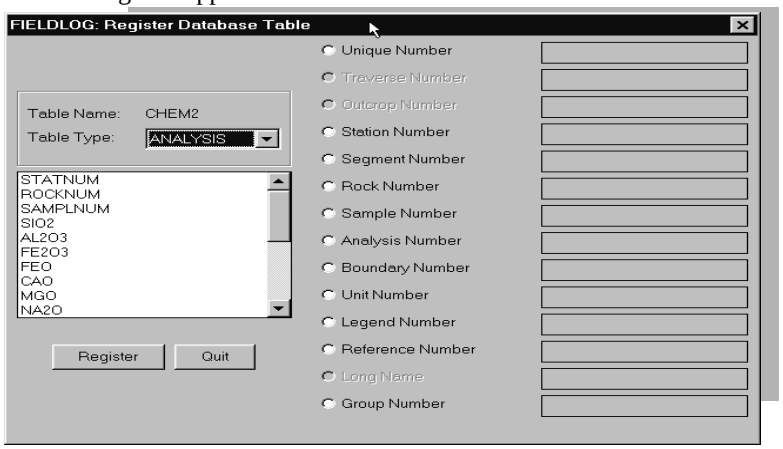
- **Table**: Select the FieldLog table you want to append/update (in this case STRUC). The columns of the STRUC table appear in the right column of the screen.
- **Column**: Select all the columns in the database column list that correspond to columns in your text file, excluding BASENUMBER. FieldLog imports text file columns by matching the first text file column with the first selected database column, the second text column with the second selected database column, and so on. Not all database columns need to be selected and there may be gaps between selections. FieldLog assumes all text columns are selected, but ignores any text columns for which there are no corresponding database columns selected (e.g., when 3

database columns are selected and there are 5 text file columns). **Note that the order of the columns in the text file MUST be identical to the order of the columns in the database.**

- **Column Delimiter**: Enter a **Column Delimiter**, usually **,** or ***TAB*** or leave *blank*. FieldLog imports data on a line by line basis. The end of a line indicates the end of a row and the beginning of a new row. Individual columns (fields) within a row are separated by a delimiting character (the column delimiter), and FieldLog considers a field's contents to consist of the characters embedded between these delimiters (e.g., for the comma delimited row 'field1, field2, field3' there exist 3 fields: 'field1',' field2' and 'field3'). This may be a problem when the delimiting character exists in the field's text as it's considered the end of a field (e.g., suppose field2 contained a comma as in 'field1, field,2, field3' then 4 fields would be erroneously recognized: 'field1', ' field', '2' and 'field3'. This problem can be overcome by using text delimiters which surround text fields and permit column delimiters to be embedded within them (e.g., using the double quote as text delimiter in the row ' "field1", "field,2", "field3" would result in three fields being recognized: 'field1', 'field,2' and 'field3'. Remember that the single quote is a special database character that, if embedded in the text, causes the row to be to rejected during import.
- **Text Delimeter**: Enter a **Text Delimeter**, usually **"** or leave *blank.* Text delimiters surround text fields, causing all the characters between them to form the contents of a field (see the discussion above).
- **Projection**: In the **Projection** field, select the coordinate system of the points in the text file. This field only becomes active if you are importing data into a table containing coordinates (e.g., in the SnowLake database, the coordinates are stored in the STATI table). The incoming coordinate system doesn't need to match the database's coordinate system, as FieldLog converts them appropriately, if possible (e.g., it converts incoming lat/long geographic coordinates to the UTM Zone 14 and User Grid coordinates of the SnowLake database).
- **Append/Update:** If you're appending data, click **Append**. Click **Update** to overwrite existing data. Update is only available when the database table and incoming data can be uniquely identified by a column value (e.g., Statnum in STATI) or a combination of column values (e.g., Statnum+Rocknum in LITHO). Update searches database tables for the matching values and if successful replaces the database columns with those from the text file. If no matching values are found, Update inserts a new row.
- **Fieldworker**: This option is only valid when importing location data files from the Fieldworker Pro data entry software (i.e., those data files that contain location coordinates). This option sets defaults for the column list, column delimiter, and text delimiter.

5. Click **Import**.

If you chose **Database** in the Import Table dialog box, the Register Database Table dialog box appears.



6. You must now register your new FieldLog table (refer to *Chapter 7: Registering Your Table* for details on *table type* and required column information).

Editing FieldLog Data Using External Databases

Using External Databases

The use of specific external databases won't be covered. Refer to the relevant database package manual. Note, however, that you must complete edits in the external database for the change to become visible in FieldLog. This automatically happens if you shut down the external database. If you want to keep the external database running along with FieldLog and AutoCAD, then you can complete the edit function in the database by clicking on another row. A 'pencil' icon in the far left column in Microsoft Access (for example) is indicative that the row is being actively edited.

When editing your project database it's often convenient and advantageous to adopt a data view format more versatile than FieldLog's (which is limited by the capabilities of AutoCAD). There are two approaches. The first approach links the FieldLog database directly to the external system, permitting either system to edit the same database simultaneously, (i.e. it's possible to edit FieldLog data in AutoCAD/FieldLog and MS-Access at the same time). The second method requires the data to be exported to an external system (in this case, MS-Access) where it is modified and re-imported into FieldLog.

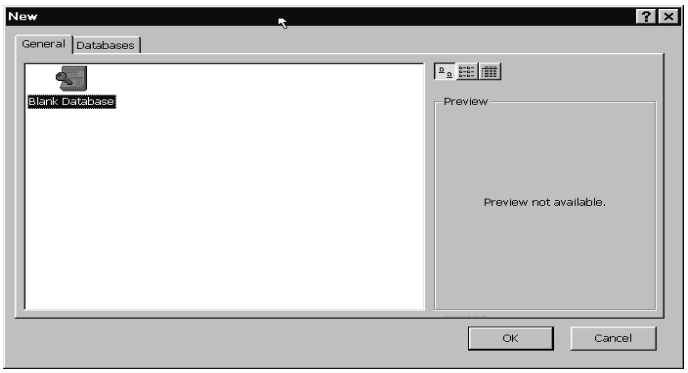
Note: It may be prudent to make a copy of your entire FieldLog database before editing it.

Editing Your Database Using MS-Access

Open up an external database. In this example we use Microsoft Access.

1. Start MS-Access.
2. Choose **File>New Database**.

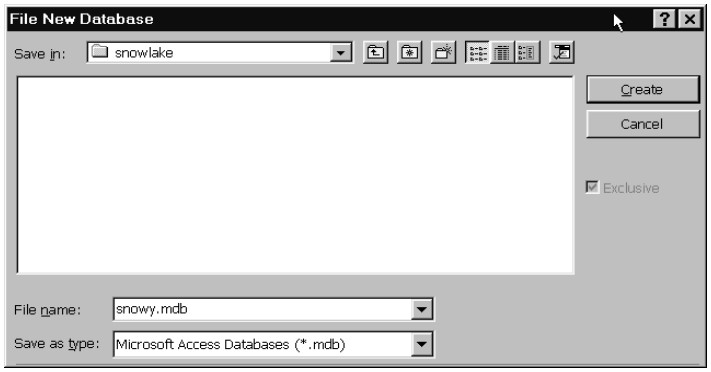
3. *Blank database* is highlighted. Click **OK**..



DBase III

FieldLog is based on the Dbase III model. All of its files are in DB3 format, and DB3 drivers are used to access data and link with AutoCAD.

4. Give your new Access database a name (e.g., *SnowLake*) and place it in your FieldLog project directory (e.g., *c:\SnowLake*); it's given the extension .mdb for Microsoft Access database. Click **Create**.



5. In the Table dialog box, click **New**.

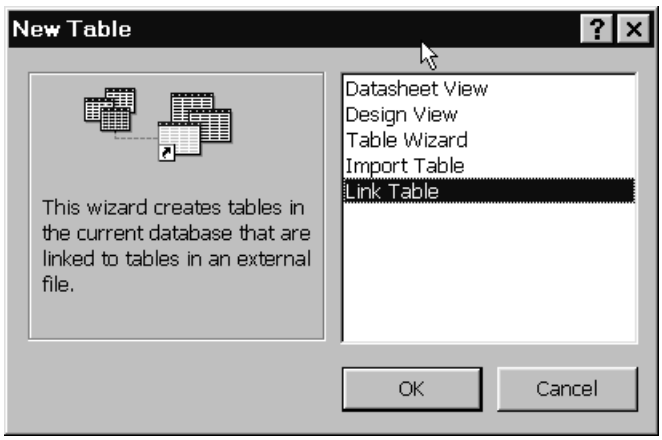
- You must now decide whether you want to:

  a) link your .mdb files directly to your FieldLog database using the *Link Table* option to enable simultaneous editing, or

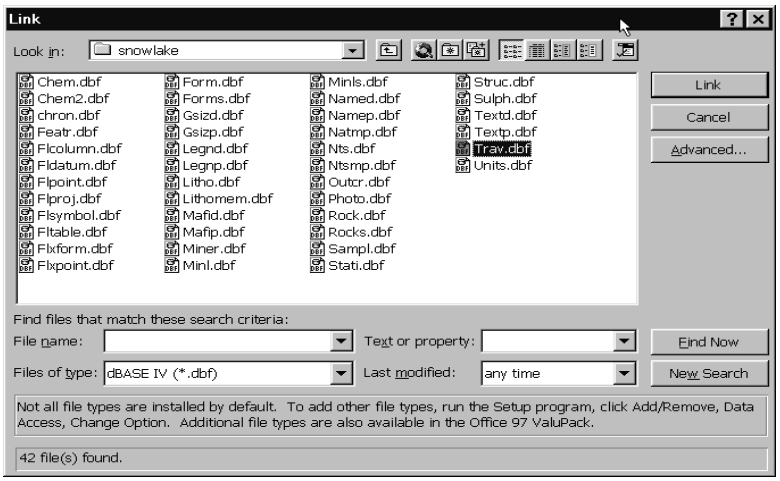
  b) import your FieldLog .dbf tables into MS-ACCESS, modifying them, and re-importing them back into FieldLog thus overwriting pre-existing files. You can do this using the *Import Table* option.

Creating FieldLog-MS-Access Links

1. To start linking tables, click **Link Table**.

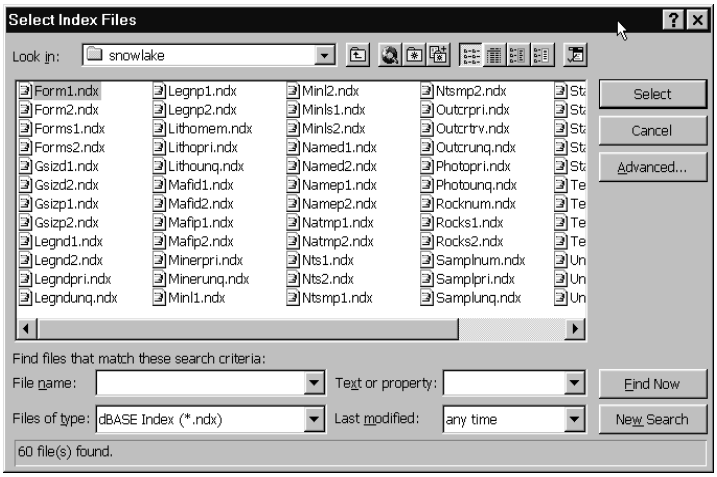


2. In the *Files of type* box, choose *dBase3*. A list of your FieldLog project .dbf files appears. Select the first .dbf file you want to link to (in this case Trav.dbf), then click **Link**.



3. You're prompted to choose an index file (.ndx) which controls the sequence of rows in the database and improves query efficiency. If you're using AutoCAD R13/R14, ignore this option and click **Cancel**. For R12 and below click all.ndx files prefixed with the name of the table you selected above (e.g., travpri.ndx), then click **Select**.

4. If the link is successful, the message *Successfully linked to table* appears. To clear this message, click **OK**. To quit linking, click **Close** (or select another .dbf to link to and repeat the process).

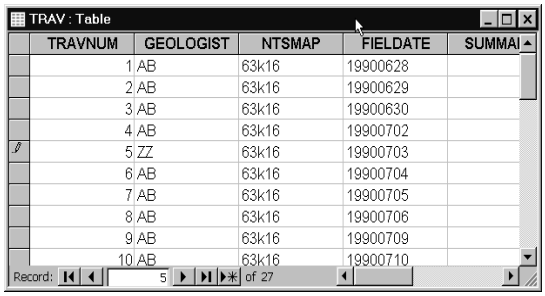


5. Open the *TRAV* table in MS-Access by selecting the **Table** tab and double-clicking *TRAV,* or by single-clicking *TRAV* and then clicking **Open.**

   Note that you aren't creating a new .dbf file, but are linking to the .dbf file resident in the FieldLog project database. If you deleted the linked file in your .mdf database file, you would only be deleting the link to FieldLog.

6. You can now edit the data. Contents of the *TRAV* table in FieldLog are modified as soon as the edits are made in Microsoft Access. Conversely, if you edit the data in FieldLog (using fl-edit or fl-query), the changes are visible in Microsoft Access.

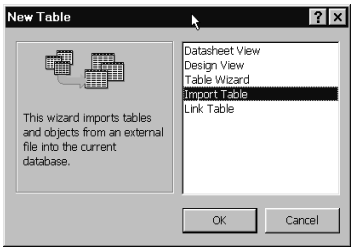
Note: Changes made in Microsoft Access aren't reflected in your AutoCAD map drawing. You must either **fl-update** your map drawing (see Update, Chapter 7) or erase the FieldLog entities and replot your data with **fl-query**.



To have MicroSoft Access running at the same time as FieldLog, simply minimize the AutoCAD window; this allows you to move easily from one package to the other.

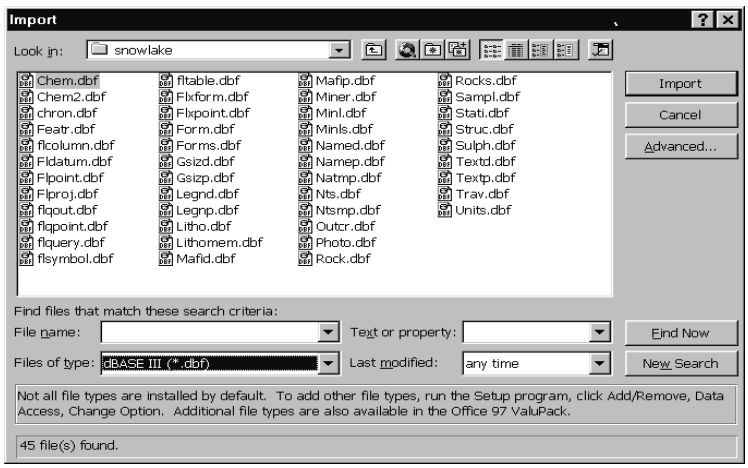
Importing FieldLog Tables into MS-Access

1. Select **Import Table** in the New Table dialog box, then click **OK**.



2. In the *Files of Type* box, choose dBase3. A list of your FieldLog project .dbf files appears. Select the first .dbf file you want to import.
3. Click **Import.**

   A *Successfully imported table* message appears.
4. Click **Close** after importing all the tables you want to edit or view.



5. Open the *TRAV* table in MS-Access by selecting the **Table** tab and double-clicking *TRAV*, or by single-clicking *TRAV* and then clicking **Open.**

Note: Your FieldLog .dbf files won't be modified unless you overwrite the original FieldLog database file with the MS-Access database file.

6. To overwrite/update the FieldLog database file with your .mdb database file, choose **File>Save As/Export**.

When you're entering/changing data in an external database, you can enter any value, regardless of whether that value is present in a FieldLog picklist or dictionary. FieldLog rules to control data entry won't be in effect. Your only data restrictions are *length of field*, as your external database uses the setup values for column character length input under *fl-setup>table setup>column> setup*. This means that you have to ensure that the **spelling** and **syntax** of your edited entries match those values predetermined in FieldLog. Subsequent queries won't include misspelled entries in a queried selection set.

Remember that changes made using your external database won't be reflected in your AutoCAD map drawing. You must either update your map drawing (see Update, Chapter 7) or erase the FieldLog entities and replot your data with **fl-query**.

Summary

FieldLog is capable of working alongside other database software, whether it is running on a handheld field computer or alongside AutoCAD on a desktop machine. Data import and export are fully supported in FieldLog but require some knowledge of table names and their internal structure.

To safeguard against error, remember to thoroughly back up your entire database project before importing data. Re-entering field data isn't fun.

APPENDIX A

Installing and Upgrading FieldLog; Creating FieldLog Symbols

Introduction

FieldLog 3 is a highly structured program that builds database links, data automation methods, and geologic reasoning tools into AutoCAD. Since it must interface with AutoCAD as well as support its own functions, installation and project creation are slightly more complex than in traditional stand-alone software.

This appendix covers AutoCAD installation under AutoCAD R12, R13, and R14, and provides summary notes on upgrading existing FieldLog version 2 projects to FieldLog version 3. It also summarizes advanced issues such as live links between AutoCAD/FieldLog and ODBC-compliant databases.

The FieldLog Distribution

FieldLog contains 14 files:

- FLG12WIN.EXE, the AutoCADR12 for Windows executable
- FL12DOS.EXE, the AutoCAD R12 for DOS executable
- FLG13.EXE, the AutoCAD R13 executable
- FLG14.EXE, the AutoCAD R14 executable
- FLG14ES.EXE, the AutoCAD R14 executable (Spanish)
- SNOWLAKE.EXE, the Sample data.
- SNOWEMP.EXE, an empty database
- SNOW1314.EXE, sample digital photos and geophysics for AutoCAD R13 and R14
- FIELDMAN.EXE, FieldLog v. 3.0 User Guide and Manual in Postscript

- SNOWARC.ZIP, sample geophysical data
- FIELDMAN.PDF, FieldLog v.3.0 Users Guide and Manual in PDF format
- FLG14ES.PDF, FieldLog v.3.0 User Guide in PDF format (Spanish)
- ASIDB3.EXE, DBASE 3 driver for AutoCAD R14.00 or R14.01
- ASIDB3.XMX, DBASE 3 driver for AutoCADR14.00 or R14.01

The first 9 are self-extracting pkzip archives and unpack into many small files when they are double clicked in Windows. The *snowarc.zip* file must be extracted either with WinZip or by using the command:

```
pkunzip -d snowarc
```

To view the PDF files, you must download Acrobat Reader.

The last two files are dbase drivers. The drivers shipped with AutoCAD R14 are unstable and need to be re-installed into your main AutoCAD directory.

There is a **FAQ** at http://gis.nrcan.gc.ca

FieldLog doesn't support AutoCAD 2000 or any of its variants.

Installing FieldLog Software, Databases, and Connecting to Databases

To use FieldLog you must install the full version of AutoCAD for DOS or Windows. Specifically, the AutoCAD database environment (ASE) must be installed correctly. If you aren't sure these are installed, reinstall AutoCAD on your machine with all options set. A full installation guarantees that all necessary components are installed.

Ensure that you have installed your latest version of AutoCAD. For R12 this means R12_c4 for Windows and R12_c3 for DOS. Earlier releases contain significant bugs.

Installation involves three separate procedures:

1. Installation of the FieldLog software package.
2. Installation of sample, empty, or preexisting databases.
3. Instructing FieldLog to recognize the appropriate database.

If you are a first-time user, you probably want to install the sample database so that you can do the tutorial. Those starting a new project will likely be use SnowLake or a pre-existing database.

Installing FieldLog

To install FieldLog under Windows 3.1, Windows 95, or Windows NT:

1. Go to the AutoCad Support directory (i.e. *\acadwin\support* for R12 windows, *\acad\support* for R12 DOS, *\r13\win\support* for R13, and *\Program Files\ AutoCAD R14\support* for R14).

2. For R12/R13, if you have a custom AutoCAD menu file stored in this directory and you have named it *ACAD.MNU,* copy it under a new filename (... *ACADold.MNU ...)* since FieldLog writes a new *ACAD.MNU* file into this directory as it unpacks.
3. Copy one of the FieldLog executables (*flg12win.exe, flg12dos.exe, flg13.exe, flg14.exe*) into the AutoCAD support directory using DOS, File Manager, or Windows Explorer.
4. Execute the FieldLog file you copied by typing its name at the DOS prompt, or double clicking the Icon in Windows Explorer/File Manager. This unpacks several files into the AutoCAD support directory.
5. For R12: reboot your system.
6. For R14.00 and R14.01, re-install dbase3 drivers by copying the two ASIDB3 files found at the FieldLog website into your main AutoCAD directory. These overwrite the somewhat unstable driver files that come with AutoCAD.

Several new files appear in your AutoCAD *support* directory, including one called FIELDLOG.DCL.

Installing Sample Data and Creating Project Directories

The files associated with a FieldLog project are stored in one directory, known as the project directory. Installing a project or creating a new project first involves creating a directory to contain the project and then, for existing projects, copying the project files into the directory and, finally, notifying FieldLog about the project's name and location. To install the tutorial data provided:

1. Make a directory for the sample data and name it *snowlake* (*e.g. c:\snowlake*).
2. Go to the sample data directory you just created.
3. Copy the file *SnowLake.exe* to this directory.
4. Extract the data by typing the filename (*Snowlake)* or by double clicking on the file's icon.
5. Get a directory listing for the sample directory. There should be many small files in the directory.

This installs the sample project data. To inform FieldLog about this sample data follow the instructions below.

Connecting to Project Databases

Setting Up a FieldLog Project Under AutoCAD R12

In order to use a project with AutoCAD R12 and FieldLog, a registration file called *FieldLog.prj* located in AutoCAD's *support* directory, and your PC's *AutoExec.bat* startup file, must be modified. A line for each project to be used with FieldLog is added to these files. These changes allow FieldLog to find the data on the PC, to determine the database type, and to assign a project name to the files found.

1. Using a word processor (such as NotePad), edit the ascii text file called *fieldlog.prj* in your AutoCAD support directory (typically this is *\acad\support* for DOS and *\acadwin\support* for Windows). It should include the following line:

   ```
   SnowLake=c:\snowlake,dBase3
   ```

   assuming c:\snowlake is the directory containing the sample data files. There should be **no spaces** in this file. Make sure you save it as an ascii text file, not as a word processor file.

2. Add the following line to the **top** of your *autoexec.bat* file, typically found in the root directory of your PC (e.g. *c:\autoexec.bat*):

   ```
   set SnowLake=c:\snowlake
   ```

   again assuming c:\snowlake is the directory with the sample data files. The only space should be after the word *set*. Save this file as an ascii text file.

3. Reboot the machine.

If you proceed through the *logon* process described in Chapter 2 of this tutorial, the *SnowLake* project should now be accessible. Successive projects are added the same way, though each project requires a unique name and distinct project directory to contain its files.

Setting Up a FieldLog Project Under AutoCAD R13 and R14

Under AutoCAD R12, the location of projects and their host database type is stored in the *FieldLog.prj* file. This file is not used by FieldLog for AutoCAD R13 and R14. In AutoCAD R13, the necessary information to locate and identify a database is stored in the *ASI.INI* file in the AutoCAD directory, and in AutoCAD R14 it is stored in the Windows Registry. These files aren't modified manually, but are instead handled by a new command (*fl-setup>Project Setup*) under the *fl-setup* menu of FieldLog (see *fl-setup* instructions listed below).

Before you can use FieldLog within AutoCAD, you must insert FieldLog into your AutoCAD menu located at the top of your screen.

1. In AutoCAD, choose **Tools>Customize Menus**.

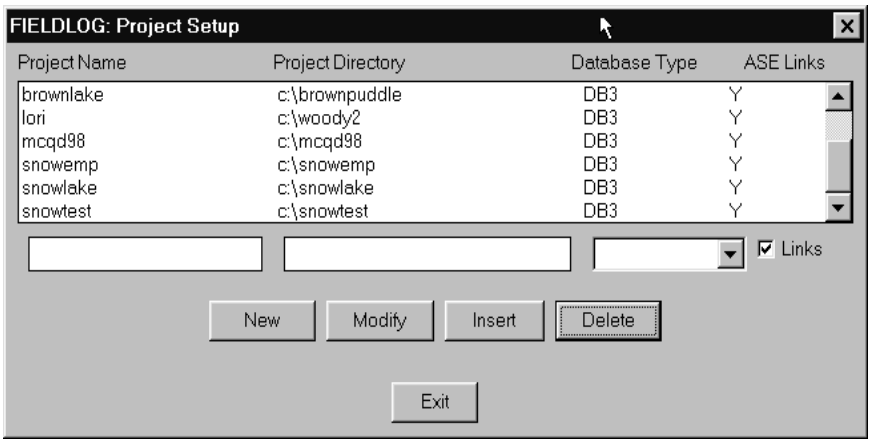
   The Customize Menus screen appears.

2. In the blank **File Name** box, type `FieldLog`, then click **Load**.
3. Select the **Menu Bar** tab.
4. From the Menu Group selection set, choose **FieldLog**.
5. Highlight **Help** in Menu Bar, then click **Insert**.

   A FieldLog menu appears on your AutoCAD menu bar, to the left of Help.

6. To exit the dialog box, click **Close**.
7. Load FieldLog from its FieldLog pull-down menu in AutoCAD. Then click the **fl-setup>Project Setup** button.

The Project Setup dialog box has four columns:



- Project Name

  This is FieldLog's name for your project. It's unrelated to actual filenames in the target directory. **Note: project names should NOT be changed once data has been added to a map within the project**, doing so nullifies the database link between the map and database.

- Project Directory

  This indicates the location of the project, either on the local PC's hard drive or on a remotely connected hard drive.

- Database Type

  This indicates the type of database that is hosting the FieldLog project. The default is dBaseIII.

- Database Links

  This indicates whether AutoCAD database links are maintained in addition to FieldLog's links. These additional links are required if the project is to be accessed from AutoCAD MAP or via the AutoCAD SQL extension.

There are four corresponding input fields: two text fields for the name and path to a new project, a pop-up menu for choosing the database type, and a toggle to turn links on and off. The **New** button empties all of the input fields in preparation for placing a new project on the list. The **Insert** button adds a project definition using the variables in the four fields. When a new project is inserted, FieldLog attempts to verify that the Project Catalogue restriction is met (see box at left), but doesn't verify that the directory exists or contains a valid FieldLog project.

Once a directory has been specified, you can log on to the database and create tables, add data, and so on.

The **Delete** button removes a project from the list, but only if it's not currently logged on. If the project removed was the last of its type (e.g., dBaseIII) the catalogue restriction is lifted for the subsequent added database. Note that deleting a project specification does **NOT** delete any of the project files, it merely makes the project unknown to FieldLog.

Project Catalogues

AutoCAD requires that project databases be arranged in accordance with the SQL '92 specification. This means that all projects hosted by a specific database type, such as dbase III, must be stored as sub-directories of a common location on the hard drive

If a specified project is stored in a directory named c:\data\field then all other projects must be subdirectories of c:\data as well.

Project Names

FieldLog may erroneously permit two projects to be assigned to the same data directory. This prevents both projects from being available. This can only be corrected via the ASICFG program, located in the ACAD support directory.

The **Modify** button allows the database directory and link setting to be changed. If the name or type of database is to be modified, you must delete the current database reference and reinsert it with a new name/type.

Note for ODBC Database Users

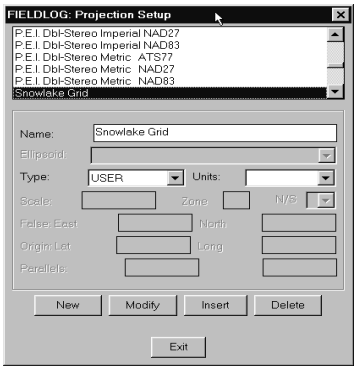
For ODBC projects registered to FieldLog, the *Directory* field must not only specify the location of the directory but also the name of the database file in which the FieldLog data resides. For example, for MS Access databases this database file possesses an *.MDB* extension (e.g., *c:\snowlake\snowlake.mdb*). The catalogue restriction applies to the location of ODBC files.

Projects must also be registered with the Windows ODBC driver. To register a project with ODBC, go to the Control Panel in Windows, and choose the *Windows ODBC Drivers* icon. The *ODBC Data Source Administrator* dialog box appears. If there isn't currently a data source called *ODBC*, click **Add** to create one. Select the appropriate driver type from the list, and then click **Finish**. Enter `ODBC` as the new data source's name, and select your database as the default data source. Click **OK** to save the data source configuration. The database should now be accessible and any other database with a similar driver will also be accessible. The name (here, ODBC) of the data source must be identical to the name of the ODBC environment which you are using in the ASI/Registry.

These steps are required for AutoCAD to function correctly with ODBC.

The Projections Project

Under FieldLog 3, the name *Projections* is reserved for a special purpose project used to maintain a library of ellipsoids, projections, and transformations. This allows users to centralize this information even if many individual FieldLog projects are being used. It also allows users to share projections with other users without risking sharing actual data. The Projections project doesn't normally have any tables other than those used for ellipsoids, projections, and transformations (i.e., *fldatum.dbf, flproj.dbf, flxform.dbf, flxpoint.dbf*).



Whenever FieldLog loads, it checks to see if a project called *Projections* has been defined. If so, it automatically loads this project and makes all of the projection information available to all subsequent FieldLog projects. FieldLog ensures that all changes and additions to the projections environment are kept in this central

location. Projection information from individual projects is then added to this projection catalog when the projects are logged on. Any changes to projection information cause all the projection information to be saved to the common location, as well as to any loaded projects. Therefore it's critical that projection information is well managed.

To create a projections project, create a new project using *fl-setup* (R13) or a text editor (R14), depending on your version of AutoCAD. Name this new project *Projections.* You may further wish to copy the projection example files from *SnowLake* (i.e., *fldatum.dbf, flproj.dbf, flxform.dbf, flxpoint.dbf*) into the directory for this new project to gain access to the wide variety of defined projections therein.

Upgrading From FieldLog v2.83 to v3.0

To update FieldLog from version 2.83 to 3.0, you must upgrade your v2.83 database and any AutoCAD maps containing data linked to that database. This is a four step process:

1. Back up your entire project onto a safe, reliable backup medium. Consider backing it up twice!
2. You must inform FieldLog where the v2.83 project can be found.

   In AutoCAD R12:

   - Add a project definition line to your Autoexec.bat as explained above for the sample data. For example:

     ```
     set MyProjectName=c:\mydatadirectory
     ```

     If you have multiple projects on this machine, one set statement in your autoexec.bat file is required for each project.

   - Add a project definition file to your AutoCAD *support* directory as explained above for the sample data. For example:

     ```
     MyProject=c:\mydatadirectory,dBase3
     ```

     If you have multiple projects on this machine, each project is described by a separate line in your *FIELDLOG.PRJ* file.

   - Reboot your system.

   In AutoCAD R13 and R14:

   - Start AutoCAD, Load FieldLog, and in **fl-setup>Project Setup** insert a new project definition specifying the project name (e.g. MyProject), its location (e.g. c:\mydatadirectory), and database type (e.g. dBaseIII). This project definition should be listed in the main panel after being inserted.
3. You may want to copy the projection definitions from the SnowLake sample dataset into your project directory. This involves copying the *fldatum.dbf, flproj.dbf, flxform.dbf, and flxpoint.dbf* files from the SnowLake project directory (i.e. c:\snowlake) into the v2.83 project directory (i.e. c:\mydatadirectory).
4. Upgrade your project database (do **all** of the following steps, carefully, in order):

a. Start AutoCAD and Load FieldLog, if this is not already done.

b. Logon with **fl-logon**.

c. Select **fl-upgrade** from the menu or type `fl-upgrade` at the command line.

d. To select the project you want to upgrade, click it.

e. To start the upgrade, click **OK**. FieldLog proceeds to upgrade each table in your database.

f. FieldLog interrupts the upgrade process and asks you load any symbol libraries you want to use with the project. If FieldLog is able to locate the OGS, NATMAP and GSC symbol libraries it automatically loads them and they should appear in the main panel. Any additional libraries can be specified at this point. Use the **File** button to locate the libraries, and the **Load** button to load them. When finished, click **Exit**. FieldLog continues the upgrade process.

g. FieldLog informs you when the v2.83 database has been upgraded to v3.0. To save the new setup, click **OK**.

h. FieldLog then asks to upgrade the map. You can upgrade your map(s) now or later. Before a map can be used with v3.0 it must be upgraded by following steps a-g, and then selecting all FieldLog created entities on the map. FieldLog then upgrades the map entities so that they are linked to the v3.0 database. Map entities created with v2.83 don't communicate with a v3.0 database until they are upgraded. **Fl-upgrade** must be performed once on the database, and once for each map associated with the database.

i. When the upgrade process is completed FieldLog notifies you that your database tables may need to be registered more accurately. This is an optional, advanced procedure. To complete the upgrade process you can register your tables more accurately by:

   - Select **fl-setup** from the menu or type `fl-setup` at the command line, then enter *Tables Setup*.
   - Select your project from the list on the right.
   - Click the **Table** option, then select the first table on the right.
   - Click **Setup**.
   - Select appropriate table types and identify key fields. Each table already has:

     a unique number field and station number field; other options:

     STATION: unique#, station#, outcrop#, traverse#

     SECTION: unique#, station#, section# (e.g. drill hole segments)

     ROCK: unique#, station#, section#, rock# (e.g. each rock at a station is numbered)

     SAMPLE: unique#, station#, section#, rock#, sample# (e.g. rock samples, photos)

     GENESIS: unique#, station#, section#, rock#, sample# (e.g. structure)

     COMPOSE: unique#, station#, section#, rock#, sample# (e.g. minerals, alteration)

     ANALYSIS: unique#, station#, section#, rock#, sample#, analysis# (e.g. thin sections, geochemistry, and so on)

   - To save your new setup, open the Fl-Setup button box, then click **Save FieldLog Setup**.

Upgrading a v3.0 Project From AutoCAD R12 to R13/R14

To upgrade from AutoCAD R12 to AutoCAD R13/R14 no special upgrade procedure is required. Simply follow the instructions above (**Setting Up a FieldLog Project under AutoCAD R13 and R14**) to inform FieldLog about your v3.0 project. However, because AutoCAD R13/R14 is SQL'92 compliant it reserves many more words than R12. If a database table name or column name uses any of these reserved words, the table won't be accessible to FieldLog's commands (e.g. *fl-add, fl-edit, fl-query,* etc.). To correct this, the improper name must be changed. This name change must be performed outside FieldLog using another database system such as dBase, FoxPro, MS-Access, and so on. The list of reserved words (with the most commonly used improper names bolded) is:

ABSOLUTE, ACTION, ADD, ALL, ALLOCATE, ALTER,
AND, ANY, ARE, AS, ASC, ASSERTION, AT, AUTHORIZATION,
AVG, BEGIN, BETWEEN, BIT, BIT_LENGTH, BOTH, BY,
CASCADE, CASE, CAST, CATALOG, CHAR, CHARACTER,
CHAR_LENGTH, CHARACTER_LENGTH, CHECK, CLOSE, COALESCE,
COLLATE, COLLATION, COLUMN, COMMIT, CONNECT, CONNECTION,
CONSTRAINT, CONSTRAINTS, CONTINUE, CONVERT, CORRESPONDING,
COUNT, CREATE, CROSS, CURRENT_DATE, CURRENT_TIME,
CURRENT_TIMESTAMP, CURRENT_USER, CURSOR, **DATE, DAY,**
DEALLOCATE, DEC, DECIMAL, DECLARE, DEFAULT, DEFERABLE,
DEFERRED, DELETE, DESC, **DESCRIBE, DESCRIPTOR**, DIAGNOSTICS,
DISCONNECT, DISTINCT, DOMAIN, DOUBLE, DROP, ELSE, END,
END-EXEC, ESCAPE, EXCEPT, EXCEPTION, EXEC, EXECUTE, EXISTS,
EXTERNAL, EXTRACT, FALSE, FETCH, FIRST, FLOAT, FOR,
FOREIGN, FOUND, FROM, FULL, GET, GLOBAL, GO, GOTO, GRANT,
GROUP, HAVING, HOUR, IDENTITY, IMMEDIATE, IN, INDICATOR,
INITIALLY, INNER, INPUT, INSENSITIVE, INSERT, INT, INTEGER,
INTERSECT, INTERVAL, INTO, IS, ISOLATION, JOIN, KEY, LANGUAGE,
LAST, LEADING, LEFT, LEVEL, LIKE, LOCAL, LOWER, MATCH, MAX,
MIN, MINUTE, MODULE, **MONTH**, **NAMES**, NATIONAL, NATURAL,
NCHAR, NEXT, **NO**, NOT, NULL, NULLIF, NUMERIC, OCTET_LENGTH, OF,
ON, ONLY, OPEN, OPTION, OR, ORDER, OUTER, OUTPUT, OVERLAPS,
PARTIAL, POSITION, PRECISION, PREPARE, PRESERVE, PRIMARY, PRIOR,
PRIVILEGES, PROCEDURE, PUBLIC, READ, REAL, **REFERENCES**,
RELATIVE, RESTRICT, REVOKE, RIGHT, ROLLBACK, ROWS, SCHEMA,
SCROLL, SECOND, **SECTION**, SELECT, SESSION, SESSION_USER, SET,
SIZE, SMALLINT, SOME, SQL, SQLCODE, SQLERROR, SQLSTATE,
SUBSTRING, SUM, SYSTEM_USER, TABLE, TEMPORARY, THEN, TIME,
TIMESTAMP, TIMEZONE_HOUR, TIMEZONE_MINUTE, TO, TRAILING,

TRANSACTION, TRANSLATE, TRANSLATION, TRIM, TRUE, UNION, UNIQUE, UNKNOWN, UPDATE, UPPER, USAGE, **USER**, USING, **VALUE, VALUES**, VARCHAR, VARYING, VIEW, WHEN, WHENEVER, **WHERE**, WITH, WORK, WRITE, **YEAR**, **ZONE**

Creating Custom Symbols in AutoCAD for FieldLog

The DXF2SHX Program

FieldLog contains libraries with variations of the most common symbols used in geological cartography (NATMAP.shx, OGS.shx and Metamorhpic.shx). However, in some cases you may need to create your own symbol library to reflect the cartographic needs of your operating environment. Creating a new symbol library to use with FieldLog involves drawing the symbols in AutoCAD, exporting them to a dxf format, and converting the dxf file to a.shx symbol library using the antiquated DXF2SHX.EXE DOS program.

The DXF2SHX program converts a DXF file drawn in AutoCAD to an AutoCAD.SHX symbol file format.

The DXF2SHX program works best with AutoCAD R12. The program doesn't convert dxf files generated from R14 (even if they are saved as R12 dxf) without some low-level recoding using a text editor/word processor.

Some rules for drawing symbols in AutoCAD:

- Each symbol and its components must be placed on its own AutoCAD layer.
- The symbol's layer name becomes the symbol name.
- Each symbol layer name should be alphanumeric and contain no special characters.
- All entities created on layer '0' are ignored, you can use this layer for annotation.
- Symbols must be constructed only from the following simple AutoCAD entities: lines, plines, circles, or arcs; do **not** use hatches or shapes.
- Each symbol must reside within a 10 by 10 unit cell; i.e. each symbol must occupy an area not greater than a square 10 drawing units long and wide.
- Each start or end point of an arc or line should occur on an integer boundary or contain no more than one decimal place of accuracy; e.g. 10.0 or 10.1 are acceptable, whereas 10.01 and 10.11 aren't.
- Each symbol must have a text entity indicating the symbol origin. This text string is oriented so that the lower left corner of the first character is the insertion point of the text, and hence the origin point for the symbol.
- To execute the DXF2SHX program, use the DOS prompt.

Some helpful guidelines for symbol creation in AutoCAD:

1. Choose **Settings>Drawing aids**.
   - Turn *grid* **on**; set *x* and *y* spacing to **0.1**.

- Turn *snap* **on**; set *x* and *y* spacing to match grid spacing.
- Click **OK**.

2. On ***layer 0*** draw a workspace box 10 by 10 units.
3. Type **pline**, then enter **0,0**
   10,0
   10,10
   0,10
   0,0

You may want to create a grid with several 10 x 10 cells, one cell for each symbol you're creating.

To create the symbol:

1. Through the AutoCAD layer manager, create different layer names for the different symbols you're creating.
2. Make the layer of the symbol you want to create *current.*
3. Create the symbol using pline or arc, taking care to start and end arcs and plines on .1 grid points.
4. Label your symbol and give it a point of origin by typing its name using dtext. The start point of the text becomes the point of origin.
5. Save the drawing file.
6. Repeat steps 2 to 5 for each symbol created

Make a dxf file:

- In R14:
  - Make a version R12.dxf and save to the *\Program Files\ AutoCADR14 \Support* directory.
  - Open the .dxf file in a word-processing package or text editor.
  - Scroll down to the 'table' section and modify the 'Dimstyle'table portion to look like this:

    ```
    0
    TABLE
    2
    DIMSTYLE
    70
    0
    0
    ENDTAB
    0
    ENDSEC
    ```

  - Save your file as a dxf (text) file.
- In R12: Save your dxf file to *\Acadwin\Support* directory:
  - Go to the DOS prompt (either using the **Start>Programs>Command Prompt** icon in Windows or 'shell out' in AutoCAD by typing **shell** and then pressing **enter** twice).
  - At the command line type:

```
DXF2SHX    DXFfilename.DXF    SHXfilename.SHX
```

- The conversion program executes quickly and ends with '*writing shapes..... done*', if all went well.
- To exit DOS, type `exit`, and press **Enter**.
- To verify the process has worked correctly, begin a new drawing in AutoCAD, load the symbol library, and insert a shape:
  - Type `load` at the command line.
  - Select your new symbol library (the newly generated .shx file) and load it.
  - To insert your symbol, type `shape`**.**
  - Type the name of your symbol.
  - Your new symbol appears, and you're prompted for the insertion point, size, and rotation of the symbol

The SHX2DXF Program

The FieldLog package also contains the corollary to DXF2SHX — the SHX2DXF program. This program converts an AutoCAD symbol library (.SHX files) into a DXF format, from which it can easily be viewed or revised.

The DXF file created by SHX2DXF contains each symbol from the SHX symbol library. In AutoCAD, each symbol occupies its own AutoCAD layer, annotated by its symbol name. The program must be executed using the DOS prompt.

At the command line, type:

```
SHX2DXF    SHXfilename.SHX    DXFfilename.DXF
```

Changing FieldLog Symbols From Shapes to Blocks

FieldLog represents symbols equally well as either AutoCAD blocks (.dwg files) or shapes (.shx files); by default FieldLog uses shapes. FieldLog MUST draw all symbols from one or more shape symbol libraries, regardless of the method of representation selected (i.e. shape vs. block). So why change the format? For symbols exported as .dxf to import correctly into other software packages, the symbols need to be initially plotted as blocks or converted from shapes to blocks prior to export. Although symbols on a map can be changed from shapes to blocks at any time during the life of a project it's easier to set/change the symbol format at the start of the project.

To change the FieldLog setup from shapes to blocks, each symbol definition in the project database requires editing. The symbols plotted to your map also need to be updated to reflect the changes in your FieldLog setup. This isn't a huge undertaking as you are probably using only a small subset of the symbology available with FieldLog. Before you start, remember to make a backup of both your database and your AutoCAD map drawing file.

To edit:

1. Go to **fl-add**.

2. Select a table that contains a column with an attached ‘list’, and where the terms in the list are symbolized (e.g. Struc.Feature in SnowLake).
3. Select **Struc.Feature**, and click **List**.
4. Select the first term you want to change, and click **Palette**.
5. Click the **Block** button.
6. Click **OK**.
7. Repeat this for all the terms you expect are, or will be, displayed on your map.
8. Exit from fl-add, and ***Save*** your setup changes with **fl-setup>Save FieldLog setup.**

To update your map symbol entities:

1. In AutoCAD, turn off and freeze all the layers except for those containing the symbols you want to update.
2. Using **fl-update**, ‘window’ the map, and press **Enter**. FieldLog applies the symbol changes and converts the shapes to blocks.
3. **Save** your map in AutoCAD.

Conclusions

This appendix provides a basic introduction to FieldLog installation and project setup. It also covers how to make a new symbol library using the program DXF2SHX, and how to convert symbols drawn as shapes to symbols drawn as blocks.

When importing FieldLog v2.83 files into FieldLog v3.0, a wide variety of minor but irritating problems can occur. Check the FieldLog web site for tips and tricks, additions to the manuals, and for information on contacting the authors.

APPENDIX B

FieldLog: Data Models, Relational Databases, and FieldLog's Database Design

A Brief Description of FieldLog

Abstract

FieldLog is a software tool developed by the Geological Survey of Canada (GSC) to aid geologists in the digital management of geologic field data. It provides a means to digitally record, retrieve, display, and analyse field observations, and to supplement cartographic map preparation and geologic interpretation. FieldLog maintains a relational database within an AutoCAD environment and connects to several popular GIS systems through export formats. It's founded on a data model which consists of geological concepts common to the mapping process. Project databases, their cartographic representation, referenced coordinate systems, and glossaries of geologic terms are completely configured and modifiable by the geologist. The data model defines much of the internal database and cartographic behaviour, insulating the geologist from many technical details and providing enhancements to traditional database and cartographic operations. Sophisticated data entry and database query, including specialized geologic diagrams, are present to augment the map-making process. Integration with mobile computing devices, as well as with more standard methods of field note taking such as traditional field notebooks, permits a broad range of data recording options. FieldLog has been an integral component of the GSC's regional mapping and rapid digital map publication methodology since 1991.

Geologic Map Construction

Geologic maps depict geologic observations and interpreted geologic objects which are often inferred from the observational data. The exact representation of these objects as map entities is scale dependent and the geometry may vary between point, line, polygon, surface, and volumetric objects. The identification or deduction of geologic objects is iterative: evidence is gathered and hypotheses are formulated which are supported or refuted by further evidence. This is an analytic process where data are mutable and prone to re-classification or re-interpretation during the course

of the mapping. In this context a field system must ultimately be an aid to the thinking process as much as it must be an efficient mechanism to record and store thoughts. Effective gathering of data is the first priority in this process, soon followed by a need to recast the data into different scenarios.

Under FieldLog a geologic map usually begins as one or more digital topographic basemaps which are originally purchased from some third party, typically a government agency. The maps may also be directly scanned and digitized. Once acquired, the base maps are registered in some coordinate system which defines their geographic position. A project database is constructed by the field geologist to contain the field data and to interact with the maps. Project databases may be derived from corporate templates or may be begun anew. Once a project database is established data can be simultaneously added to the maps and to tables in the database. In this process field data may be displayed on several maps and a map may contain data from several projects. Though FieldLog allows several projects to be active during a session, its functions only operate on one project at a time. For instance, query contents can't be selected from more than one project in any one query.

Field observations typically are sites or boundaries, and these are added to the base map as points or line segments. Their attributes are entered into the database at the same time. These supporting data are manually entered into the FieldLog database from field notebooks or forms, or are digitized from air photographs and topographic maps using small digitizing tablets. They may also be imported from mobile computing devices such as GPS (satellite-based Global Positioning Systems) and PDA (hand-held Personal Digital Assistants) or more sophisticated portable units. Some of the data are symbolized on the map — either via manual digitization or through importation and plotting via queries — and some of them reside in the database as supporting evidence. This data entry stage typically involves the entry of site information into the database and the display of select portions on the map. Boundary data may also be recorded and digitized at this time. Mesoscopic observations such as station locations, structural measurements, and rock type characteristics are recorded and plotted with FieldLog, and macroscopic observations such as contacts, folds, and faults are drawn using AutoCAD's line and polygon drawing mechanisms — they may also be imported from pre-existing digital geology maps or from portable field computers. Once in digital form, the evolving map is typically plotted at scale on a regular (i.e. daily) basis using page size printers. The plotted pages are joined, often with tape, and this growing paper mosaic represents the field map. Often interpretive features, such as geological contacts, are sketched by hand onto this mosaic, and subsequently digitized when and if confirmed. As the geological story unfolds, the various hypotheses — depicted as disconnected boundaries on the map — are joined to form polygons which eventually partition the geographic extent of the map. In this process observed supporting data are often reclassified using FieldLog's editing capabilities which ensure that map and database equivalency is maintained. AutoCAD's standard functions are used to edit all non-FieldLog data.

The evolution of geologic insight for a map area often involves the utilization of tools such as stereographic plots as well as geophysical overlays. FieldLog provides either the resources to perform these tasks or to export the data painlessly so that it can be further integrated into more sophisticated and specialized systems such as GIS or other geological plotting packages. Ultimately the results of such deliberation are returned to FieldLog as new

geologic objects on the map, or as changes to existing map entities. The end result is a geologic field map with an underlying database of field observations.

Data Entry

FieldLog maintains field observations in a relational database which is linked to one or more digital AutoCAD maps. In a typical project most field data are stored in the relational database, and a subset of these data are displayed on the map. However, some map entities, such as geological boundaries, may exist solely as cartographic objects without being additionally described in the field database. FieldLog permits map entities of any geometric shape (e.g. points, lines, or polygons) and cartographic type (e.g. symbols, text, lines, and so on) to be described in the database. Furthermore, the data entry process allows point entities to be simultaneously added to the database and map as symbols or text. This procedure doesn't hold for other map entities such as lines or polygons: they must first be added to the map using AutoCAD's standard cartographic functions and then linked to a database description during data entry. Each AutoCAD map, and thus each map entity, has positional information referenced to a previously established coordinate system taken from FieldLog's catalogue of cartographic projections. Positional information is copied from the map to the FieldLog database only for designated points, whereas positional information for other map entities remains in the AutoCAD map.

When entering data, field observations may be typed, locations may be digitized, and either can be imported from external text or database tables. A digital topographic map is usually used as a backdrop onto which the observations are plotted. When observations are imported from external sources such as mobile data collection devices, they are retrieved from the database and plotted to the map via a user directed query process. When observations reside in paper notebooks or forms, they are manually entered by selecting a table and entering information into the columns of a new row. Column contents are verified according to various parameters configured by the geologist. If verified, the new row is inserted into the table and the values of selected columns are optionally positioned on the digital map through visual location or via digitization from some source such as a topographic map or air photograph. When several observations occur at a site, the data may be stored in more than one table or in more than one row in a table. In this case FieldLog propagates critical values between rows, or from one table to another, in order to reduce data entry time and to enforce proper data connectivity between database tables (i.e. referential integrity constraints). For example, site identifiers propagate to all rows and tables until a new site is specified. FieldLog also permits customizable dictionaries of geological terms to be created and attached to columns for data entry purposes (Fig. B-1) and for the maintenance of semantic consistency of terminology. Once a dictionary is attached to a column, the contents of the column are restricted

to one or, optionally, more terms from the dictionary. Dictionaries are unlimited in the number of terms they may contain.

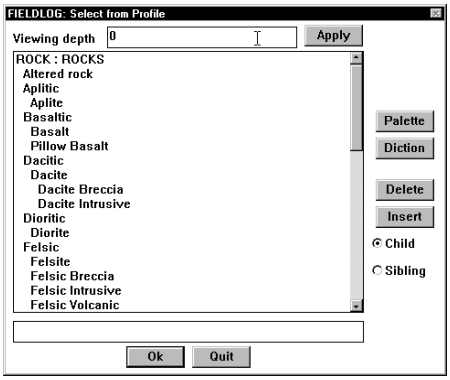


Figure B-1. Data entry using a hierarchical profile.

Mobile Computing

FieldLog v3.0 takes advantage of affordable pen-based data entry technology offered by the Apple Newton by exporting a field database structure to the Newton and importing collected data from it. The FieldLog database format is transferred to the Apple Newton where it is displayed intact, including all relevant hierarchical profiles (Fig. B-2). Commercial software (Fieldworker) operates on the Newton to receive the FieldLog project template and present it for data entry. Data may be hand-written on a touch-sensitive screen, or typed on a small, screen resident keypad. A GPS can be connected to the Newton and its locations directly read by the Fieldworker software, permitting complete data entry to occur in the field. The resultant data are exported to FieldLog in a specialized text file format and are merged into the project database. FieldLog interfaces to mobile computing devices other than the Apple Newton using standard import/export formats. FieldLog v3.0 has also been successfully utilized on the outcrop via portable pen-based computers operating AutoCAD under the Windows 95/NT operating systems.

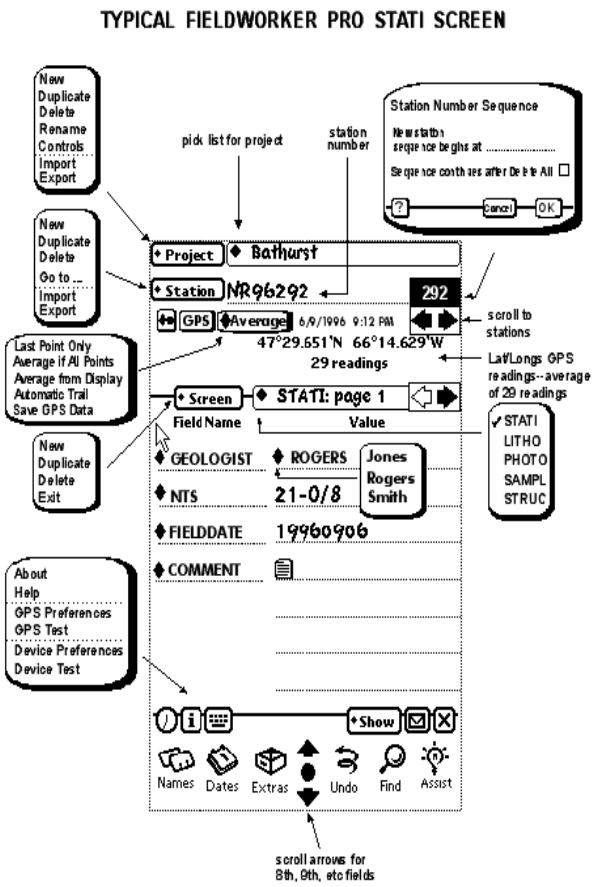


Figure B-2. A FieldLog project database on the Apple Newton, using the Fieldworker software for data entry. The Station table is displayed.

Operating Platforms

FieldLog operates in AutoCAD's cartographic environment which it extends to include additional geographic and geologic processing capability. AutoCAD was chosen because of its popularity, its cartographic excellence, its liberal development environment, and its ability to run on many hardware and operating system platforms. Of the operating systems supported by AutoCAD, FieldLog currently functions within DOS, Windows 3.1, 95, and NT. It currently uses all current versions of AutoCAD including releases 12, 13 and 14.

FieldLog can interact with a variety of database systems, primarily because all relational database activity is performed transparent to the geologist using SQL (Structured Query Language), which is platform independent. Relational databases such as dBase, ODBC (e.g. MS-Access), Oracle, and so on, are thus accessible from this modern client-server environment.

Database Query

Queries are performed using a visual interface which permits the user to thematically filter the database and view the results in tabular form. Database filters are constructed using conditional statements which are composed of thematic, spatial, or hierarchical components and which are connected with 'AND or 'OR' logical operators (Fig. B-3a). Query results are displayed as a virtual table (Fig. B-3b). Row contents in the resulting table may be browsed, deleted and modified singly or globally. The results may also be plotted to the active AutoCAD map using customized geological map symbols (Fig. B-3c), they may be manipulated to produce custom diagrams (i.e. stereonet, rose, geochemical, and pie diagrams) and may be exported to a variety of formats. Supported query export formats include tabular representations as text files and database tables, as well as direct translations to GIS using the following exchange mechanisms: ArcInfo/ArcView E00, MapInfo MIF, and SPANS TBA formats. The user can designate which columns to export and can scale the symbology or alter the coordinate system for each type of format.

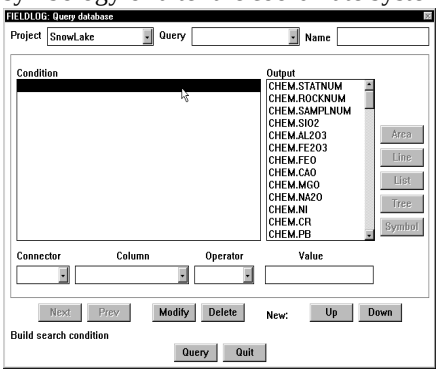


Figure B-3a. Query menu.

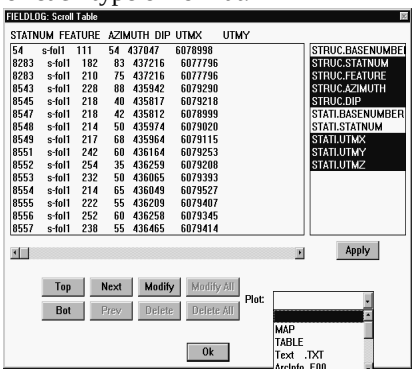


Figure B-3b. Query results + plot.

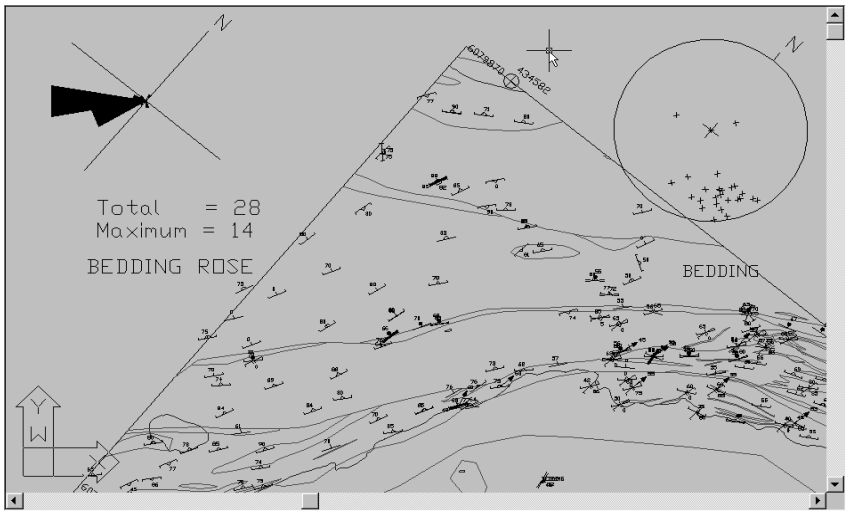


Figure B-3c. Query results plotted as symbols, rose and stereo diagrams — overlain on geological contacts.

Coordinate Systems

FieldLog permits ellipsoids, projections, and transformations to be created and modified. In this way it's possible to create a personalized catalogue of coordinate systems. Projections are restricted to variations of the following basic kinds: geographic, transverse mercator, universal transverse mercator, lambert conformal conic, double stereographic, and user defined coordinate systems. Coordinates and map entities can be converted from one projection to another. Transformations may further be defined to convert coordinates from a user grid to other grids or orthogonal projections

Distribution

Currently FieldLog is distributed electronically at no cost, on an 'as is' basis, from the following Internet address: http://gis.nrcan.gc.ca. You must complete a registration form before downloading the software. You can also purchase a bound version of the users guide and tutorial as a GSC Open File from the GSC Publications office February 2001. This manual is available, and will remain available in the future, in electronic formats on the Internet site. Formal software support is not provided by the GSC, but the author will respond to questions and comments regarding the software. Short courses on its use are occasionally presented at scientific meetings and at the GSC.

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Data Models

What is a Database?

In its simplest form a *database* is a collection of *data* that are related in some manner. A *database management system* (DBMS) permits this data to be stored and manipulated by a computer. The manner in which the data is conceptually organized, stored, and managed largely depends on the type of database system being employed: *relational database management systems* (RDBMS), today's most prevalent system, manage data in tables whereas emerging *object-oriented database management systems* (OODBMS) use objects. *Network* and *hierarchical* database systems are alternatives that are less commonly used.

Data Models

Database systems are distinguished by their rules for data organization (their *data model*) and by the way these rules are implemented (their *data definition* and *data manipulation languages*). Relational database systems adhere to the *Relational Data Model* (Codd 1970), and typically use a language called SQL (Structured Query Language) to create and manage databases. SQL exists in two formal versions: SQL'89 (SQL1) and SQL'92 (SQL2). Object-oriented systems are less well defined, but many adhere to an evolving object model (Cattel 1996) that proposes a syntax for database definition (ODL) and another for database manipulation (OML): these are typically implemented in conjunction with existing object-oriented programming languages such as Java or C++. The emerging SQL3 standard attempts to bridge the gap between the relational and object worlds by providing a common database language. However, it's still in development.

Data Modelling

Modelling is a complex task which attempts to capture the intricacies of real-world situations, including the characteristics of real-world objects, events, and object-event interrelations. Modelling by its very nature is from a particular point of view, often a combination of the view of an expert in the system being described (the earth, wildlife, surface geology...) and an expert in implementing models on computer systems (databases, forward modelling,...). Thus the modelling process occurs at many levels of abstraction for any described situation. In a geological mapping situation the real world objects modelled typically range widely from the details of individual observations, to their interconnections, to their synthesis into explanatory structures.

When the modelling process is intended to produce a data manipulation framework, the conceptual setting in which it occurs is typically called a data model. A data model is formally defined as a set of fundamental conceptual objects and mathematical and logical rules that govern their behaviour. The rules are usually expressed in terms of how and why objects may exist, and what interactions are permitted (Codd 1980).

The formal objects and operators of a data model are generally abstract in nature and form a language in which real world situations may be expressed. Generally such languages are intended to be mapped into computing

constructs, easing the transition from the real world to the abstract and finally to the computer. This process usually requires the identification of key concepts within a specific real-world domain (as seen through the eyes of an expert) and an expression of their interactions using the data model's conceptual objects and operators. In this sense, a data model may be seen as a tool kit composed of concepts, operators, and their rules of behaviour, all used to describe some real world phenomenon for computing purposes. In its most abstract sense a data model provides the logical framework in which the real world may be described for computing.

However, there exist many possible levels of examination in this process. At one level it can be described as a rigorous, abstract notation for describing some real world domain, and on another level, it can be seen as way of organizing and manipulating data pertaining to the real world domain at the physical level of the computer, in terms of bytes, records and files. Any one of these perspectives are commonly referred to as a type of data model. Hence, the term *data model* is often used to describe the product of a modelling process, usually as a database design for a particular real world domain, as well as the method and rules of abstraction used to generate such representations of reality. For instance, it isn't uncommon to speak of geometric data models or geological data models — these are each abstractions containing domain-specific concepts and rules that are widely applicable. In another sense, however, the computing paradigm in which the models are formed, be it relational, object-oriented, or some other, is also a data model (of a data model, i.e. a meta-model such as UML) (Rumbaugh et al. 1999) as it describes how the domain models are created and how their architecture behaves.

In some cases the domain specific model is called a *database model* (Burrough 1992; Teory 1988) as database design is the ultimate purpose at hand. This notion of the model being directly expressed as a database design may be attributed to the seminal work of Codd on relational databases (Codd 1970), which has caused data modelling to become inextricably linked with database design. As a result, the relational data model has become the standard example of a data model.

This initial notion of a data model providing both a conceptual framework as well as a logical mapping into computing constructs has been under review for some time. Computational driven frameworks, usually expressed in form of an algebra with mathematical operators, as in the relational model, are seen as being generally insufficient in expressing many semantic relationships between data. Because of this, conceptual models use semantically richer, often non-mathematical operators. However, this results in their translation to computing environments being more complex or impossible to implement with commercial systems. In fact, semantic models are often generalized to logical models such as the relational model, which in turn may be implemented with more ease directly on a computer. The generalization of a domain-specific and operator-rich semantic model to a logical model is fraught with difficulties.

The semantic-logical split in design leads to the concept of abstract modelling occurring at two levels, the conceptual and the logical. Each may in fact use a separate underlying *data model* for their expression and are in fact quite removed from the specific details of the computing environment. In addition, the specific physical configuration of the computing implementation may also be considered, and this third layer is referred to as a physical model. It's also often referred to as

a *data structure* (but also inadvertently as a *data model*) being a computing oriented description of some logical data model.

The results of a modelling process must ultimately be applied in a computing environment, be it spatial (GIS — Geographical Information System) or non-spatial (RDBMS — Relational Database Systems, Object-Oriented Database Systems), or both. Before this can occur a model must first minutely and exactly describe the type and behaviour of the information to be managed by the database. This process usually involves the undertaking of *requirements analysis* and *database modelling*, resulting in a particular database design for a given subject area and set of data. Once a design is formulated it can be initiated within a database system, the resultant database can be populated with data, and finally, the database becomes useful for thematic querying. It's important to design and populate the database for optimum querying, both in terms of conceptual completeness as well as performance efficiency. A bad database design can result in slow, incomplete, or incorrect responses. Database design is generally conducted in stages consisting of *requirements analysis* and *data modelling*. The needs of a subject area are identified during the requirements analysis and these in turn lead to the identification of critical concepts, their interactions, and other implementation criteria, all of which constitute the database model. Database models are, as discussed, usually described at the three levels of semantic/conceptual, logical, and physical models (Frank 1992). These are summarized below.

Conceptual Modelling

Conceptual Modelling strives to depict a real world subject area according to how the user perceives it. A comprehensive description of the subject area is constructed by isolating key concepts and by describing their static and dynamic properties. Static properties represent a concept's descriptive characteristics and dynamic properties describe the actions it may undertake, including its interaction with other concepts. Using a language analogy, static properties are nouns and dynamic properties are verbs. For instance, static properties of visible objects are, crudely, observable features while dynamic properties describe what these features can do, how, and when they interrelate, and how they react when other properties are changed. In general, a complete conceptual model for a system approaches being a complete physical-chemical model of the system, and in many cases is unobtainable.

There exist many conceptual modelling methods. They vary in the types of interactions permitted between concepts, and how the concepts are described. In addition, each method possesses a diagramming technique for its presentation. All conceptual modelling methods strive to be unaffected by the type of database to be employed; however, today's most popular commercial methods tend to be oriented to one database framework or another. For instance, *Entity-Relationship* modelling is oriented to relational databases. Concepts are called *entities*, interactions between them are *relationships*, and a concept's compositional characteristic is an *attribute*. *Object Modelling*, on the other hand, refers to concepts as *objects*, to interactions as *associations*, to behaviour as *methods*, and to an object's static characteristics as *attributes*. Theoretically it's possible to implement the various types of conceptual models within any database system, but in practice it's often easier to match conceptual model types to specific

database systems. In effect, commercial implementations of conceptual diagramming techniques have blurred the boundary between conceptual and logical models.

Logical Modelling

Unlike conceptual models, logical models tend to refer to a specific type of database system. They are in this sense a step toward actual implementation. Whereas a conceptual model describes a real world subject area abstractly, a logical model refines the conceptual model for use with a specific type of database system such as the relational or object-oriented systems. A logical model for a relational system describes the key relational elements: *entities, relations, attributes, primary keys, foreign keys*, *integrity* and *referential constraints*, and so on — everything, in fact, required to describe a working design in the relational paradigm. The analogous object logical model would describe *objects, relationships, attributes*, and *methods*.

A logical model doesn't describe the details of how the database is to be physically arranged in the computer, which is the realm of the physical model and so is somewhat abstract. Logical modelling uses diagramming techniques similar to conceptual modelling, although with a greater focus on specifics of database content and arrangement, and so is somewhat removed from the domain expert's conceptual model of the system observed.

Physical Modelling

The physical model specifies the details of implementing the logical model in a specific database type and on a specific computer system. The physical model is thus concerned with the physical implementation of the logical model. For instance, attributes are assigned a *data type*: integer, real, fixed-length character string, or variable-length character string, and so on. Collections of such attributes are stored as *records*. A series of records on the computer is called a *file*, while in a relational system a series of records is called a *table*. The physical model also usually strives to optimize the performance of the database by organizing the physical aspects of the implementation in the most favourable manner. Typically considered is the physical distribution of the database: its partitioning onto one or more computers, the clustering of certain database portions, various indexing techniques, and so on. These options are highly database specific. Often they cause the logical model to be rethought. In fact, database design is typically a cyclic process where any aspect of the overall model may be refined based on issues encountered in any of the conceptual, logical, or physical levels. The cycle is the result of ongoing interaction between the users of a system, the domain expert(s), the database designer, and the database manager for the project.

Geographical and Geometric Modelling

Traditional business database systems treat a concept's properties as discrete attributes, often grouped in tables (in the relational model) to optimize performance or query potential, or for other considerations. Spatial data, however, has the added complication that many attributes aren't business concepts (like sales, revenue, or names) but represent physical objects that not

only have physical characteristics (composition, temperature...) but also have spatial extent. Extent includes such considerations as the semantic basis of any concept, the nature of its connectivity to other objects and to its neighbours in space, and the temporal changes that it may undergo.

At the logical and physical levels, real world entities must be represented in a fashion amenable to flexible and rapid access and analysis, and this places serious limitations on which conceptual models can be translated into valid logical models. In GIS, historical efforts concentrated on the logical and physical models which have led to two alternative and 'allowable' conceptual approaches to representing spatial objects — the continuous-surface and the discrete approach. (Goodchild 1992; Frank 1992; Burrough 1992).

In brief, the continuous (i.e. raster) approach models spatial objects by subdividing space into numerous cells, usually a regular orthogonal grid, and associating attributes with the cell locations directly. The discrete (i.e. vector) approach models spatial objects as points, lines, polygons, surfaces, and enclosed volumes. Attributes are associated with whichever data type makes the model the most flexible and conceptually clear.

At a more abstract level, many representations of physical objects are a mix of continuous and discrete models, and as these approach being true conceptual models they may become difficult or impossible to implement directly (Frank 1992). In fact, each of the two general approaches can be described in terms of more abstract stratagems by which spatial reality is conceptualized. Frank lists several such perspectives (sets of points, surfaces, euclidean constructions, partitions, cells, graphs, cognitive spaces, and so on) and notes that they can't often be implemented directly — they are effectively conceptual models of geographical reality (Frank 1992).

Their implementation requires finite constraints that give rise to certain geometric objects and mathematical relationships. For instance, Frank notes that the partition concept, which embodies the notion of a space segmented into connected and non-overlapping regions, can be implemented in a topological data model composed of node and edge primitives. These primitives respect certain topological relations from which spatial properties such as adjacency, overlap, and intersection can be calculated. This set of topological rules and mathematical operators forms the logical framework for the partition concept.

The various means of actually implementing these rules and operators constitute a physical model which can also be referred to as data structure. For example, the TIN (triangular irregular network) structure is an example of a specific implementation of the partition concept and its logical design. TINs use a topological data structure consisting of interconnected triangles of varying size and with shared edges to represent a surface.

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The Relational Data Model

Relations

The relational data model is the theoretical backbone of relational databases. It formally defines the rules which underlie most relational database system behaviour. These rules are expressed using mathematical concepts borrowed from set theory. In the relational data model *relations* are analogous to *sets* and are manipulated using the set operators union, intersection, difference, and product, as well as the additional relational operators select, project, join, and divide. A relation consists of many *tuples* and each tuple contains the same number of *attributes*. Attributes are usually named and are selected from a set of possible scalar values, called a *domain*. Thus it's possible to speak of a relation definition consisting of attribute names and their domains, as well as the relation occurrence which consists of many instances (*tuples*) of attribute values. Consider the following relation definitions:

STATION (SITE_ID, X_LOCATION, Y_LOCATION, DATE)

LITHOLOGY (SITE_ID, ROCK_ID, ROCK_TYPE, DESCRIPTION)

For a particular field site, the STATION relation records as attributes an identifier (SITE_ID), a location (X_LOCATION, Y_LOCATION) and a date of observation (DATE). Each observed rock type at that station is enumerated and described in the LITHOLOGY relation with the following attributes: the site identifier (SITE_ID), the number of the rock type at the site (ROCK_ID), the rock type name (ROCK_TYPE) and its description (DESCRIPTION). The *domain* for SITE_ID and ROCK_ID may be the set of positive integers 1...n, whereas the *domain* for rock types may consist of the set of allowable rock types: "granite", "basalt", and so on. A final type of attribute value which applies to all domains is the NULL value — it signifies the attribute value is undefined. For instance, a NULL date value in the

STATION relation indicates the date on which the station was visited is unknown. The actual relations could resemble the following:

STATION { (1, 100, 100, 06/06/96), (2, 200, 200, 06/06/96) }

LITHOLOGY { (1, 1, “granite”, ““), (1, 2, “dacite”,””), (2, 1, “granite”,””), (2, 2, “rhyolite”,””) }

Two stations, each containing two lithologies, are described above. Thus the STATION relation contains two tuples and the LITHOLOGY relation contains four. The number of tuples is the relation’s *cardinality*, whereas the number of attributes in each tuple is its *degree.*

Tables

In actual database systems, relations are depicted and implemented as tables. A relation corresponds to a table, a tuple corresponds to a row in the table, and an attribute corresponds to a column in the table. Note the tabular representation of the STATION and LITHOLOGY relations in Figure B-4:

STATION:

SITE_ID	X_LOCATION	Y_LOCATION	DATE
1	100	200	06/06/96
2	200	200	06/06/96

LITHOLOGY:

SITE_ID	X_LOCATION	Y_LOCATION	DATE
1	100	200	06/06/96
2	200	200	06/06/96

SITE_ID	ROCK_ID	ROCK_TYPE	DESCRIPTION
1	1	granite	
1	2	dacite	
2	1	granite	
2	2	rhyolite	

Figure B-4. The STATION and LITHOLOGY relations as tables.

Domains are often implemented as column constraints by specifying a range of acceptable values for a column (e.g. 1...n), or by relating a lookup table containing acceptable terms for the column (“granite”, “dacite”,...,and so on). Although analogous, tables and relations aren’t equivalent. The order of tuples or attributes is unimportant to a relation, whereas it does matter to a table. Duplicate tuples are disallowed, whereas duplicate rows may be permitted in tables, though strictly speaking it isn’t good practice. When a table is physically stored on a

computer, it's often referred to as a *file* and its components become *records* and *fields* instead of *rows* and *columns*, respectively. Most users are typically confronted with the tabular (i.e. logical) representation of a relational database system, as the physical and conceptual layers usually remain hidden. The following is a list of commonly used, loosely equivalent, terms:

RELATIONAL	TABULAR	PHYSICAL
Relation	Table	File
Tuple	Row	Record
Attribute	Column	Field

Implied in the definition of a relation is a sense that the relation embodies a distinct type of entity, such as a station or a lithology, and that a collection of such relations constitute a database which is thematically related, such as a set of geological field observations. A relational database may then consist of many related tables, each representing some distinct entity type and each populated with instances of that type. For example, the station table contains instances of field stations and the lithology table contains observed lithologies. The totality of the tables forms a database that is thematically complete. To achieve this, database systems must also provide the means to define and enforce the relationships between tables, and in this way model the behaviour between the entity types. For instance, field sites and lithologies are related in that lithologies are observed at distinct field sites. *Referential integrity constraints* are the mechanism by which relational systems model such, and other, relationships. They require a relation's *primary* and *foreign keys* to be identified.

Primary Key

Inherent to the sense that a relation embodies a distinct type of entity is the notion that each tuple within the relation is unique. A field site has its own identity which can never be shared with another site; likewise a lithology observation at one site can't also be a lithology observation at another site (providing the sites are distinct) — the two observations may be similar, may even be expressed using identical wording, but nonetheless they are two distinct occurrences. The relational database model formalizes this concept by requiring each tuple to contain one or more attributes which in combination are unique within the relation. Thus relations can never have duplicate tuples. This unique attribute, or combination of attributes, is called the *primary key*. For instance, in the STATION table each field site is assigned a unique station number called SITE_ID; its uniqueness qualifies it to be the primary key. Likewise, in the LITHOLOGY table, multiple rock types may be observed at each site and each rock type is uniquely numbered *within* each site. The first rock type at a site is '1' or 'A', the second '2' or 'B', and so on. The combination of SITE_ID and ROCK_ID therefore form a distinct combination of attributes for the LITHOLOGY relation, and thus form its primary key. These types of primary keys are often also called *natural keys*, as they are composed of attributes naturally recorded with each entity. Sometimes it's necessary to introduce an artificial attribute into the relation in order to establish a primary key. Consider the STRUCTURE relation below, which records structural measurements:

STRUCTURE (SITE_ID, FEATURE, AZIMUTH, DIP_PLUNGE, ROCK_ID)

Like lithologies, structural measurements are recorded at field sites and thus this relation contains a site identifier (SITE_ID). It also contains a description of the measurement by documenting its type (FEATURE) and its geometrical emplacement in terms of its intersection with horizontal (AZIMUTH) and the vertical (DIP_PLUNGE) planes of the earth's surface. A lithology identifier (ROCK_ID) is included in order to indicate the host lithology. It's quite possible in this relation to have duplicate tuples, as distinct structural measurements at a station could have identical attributes:

STRUCTURE { (1, foliation, 200, 20, 1), (1, foliation, 200, 20, 1),...}

A primary key can't be established for this relation without introducing another, artificial, attribute to distinguish between structural measurements containing identical attributes at a site:

STRUCTURE (SITE_ID, STRUCTURE_ID, FEATURE, AZIMUTH, DIP_PLUNGE, ROCK_ID)

In practice this artificial attribute, STRUCTURE_ID, could be employed as a counter for the structural measurements at a site, much like ROCK_ID enumerates the rock types at each station from1...n or A...Z or it could simply be employed as a global counter of all the structural measurements in the relation, this in fact being an enumeration of the number of tuples in the relation (or rows in the table). The decision to use one or the other method is largely dependent on whether another relation exhibits a existential dependency on STRUCTURE, that is, on whether another relation requires each structure within a site to be identified. It's easier, though arguably less *natural*, to simply enumerate the structures within the scope of the whole relation than to enforce enumeration of the structures within each site. Both options would lead to the establishment of a proper primary key (shown in boldface below). Enumeration within a site generates a composite primary key consisting of SITE_ID and STRUCTURE_ID, whereas enumeration of the tuples in the relation produces a single primary key of STRUCTURE_ID:

STRUCTURE (**SITE_ID, STRUCTURE_ID,** FEATURE, AZIMUTH, DIP_PLUNGE, ROCK_ID) STRUCTURE { (1, 1, foliation, 200, 20, 1), (1, 2, foliation, 200, 20, 1), (2,1, lineation,300,30,NULL),...}

or

STRUCTURE (SITE_ID, **STRUCTURE_ID**, FEATURE, AZIMUTH, DIP_PLUNGE, ROCK_ID) STRUCTURE { (1, 1, foliation, 200, 20, 1), (1, 2, foliation, 200, 20, 1), (2,3, lineation,300,30,NULL),...}

A primary key in a relation provides what is commonly called *object identity* — a means of uniquely identifying each tuple in a relation or row in a table. It reinforces the implied sense of the relation as a collection of distinguishable, similarly attributed objects. Because of this, attribute values which form part or all of the primary key in a tuple may not have a null or blank value, and must comprise a unique value for each tuple in the relation. A relation may contain more than one set of attributes which provide object identity — each of the attribute sets may be called keys, superkeys, or candidate keys. The selection of a primary key from these is typically arbitrary, unless there are overriding semantic reasons to prefer one over the other.

Foreign Key

Primary keys don't capture any sense of the association between relations — this is the purview of *foreign keys*. A foreign key documents how a relation interacts with another relation, describing its *existential dependency* on the other relation. A relation is existentially dependent on another relation if it is inconceivable for the first relation to exist without the presence in the database of the second relation. For instance, it would be meaningless to associate lithology observations or structural measurements to a non-existent site; field observations are fundamentally dependent on the site at which they were observed. Removing the site from the database invalidates any related observations. Field data typically contains other existential dependencies, such as samples and mineral observations with lithologies and analyses with samples and therefore also with lithologies.

It's possible for relations to be associated without being existentially dependent — they may in fact be simply related. For example, in some databases most rock samples are collected at well designated field stations, however, it may also be permissible within this database for a rock sample to be collected without defining a formal field station.

These rules between relations are called *referential integrity constraints*. Referential integrity is inherently included in the foreign key concept. To maintain referential integrity between tables, a foreign key consists of one or more attributes that match a primary key in another table.

Foreign keys are necessary because in the relational model a concept is often distributed amongst more than one relation. For instance, in the examples above, the field station concept is represented by the totality of the STATION, LITHOLOGY, and STRUCTURE relations. This fragmentation generally occurs for two reasons: technically, because it improves database performance, and conceptually, because the fragment relations also represent concepts with individual importance. By linking these fragments with foreign keys the notion of a composite concept — i.e. the field station — is retained without losing its individual components. In practice the composite concept often stems from a central relation, and the relations composing the concept are related via the presence of common attributes which are in fact foreign keys. For example, each of the STATION, LITHOLOGY, and STRUCTURE relations contain a station number (SITE_ID) identifying the site. This station number is the primary key for the STATION relation, but comprises only part of primary key for the LITHOLOGY or STRUCTURE relations. Because foreign keys must relate to a primary key, the station number attributes in the LITHOLOGY and STRUCTURE relations are foreign keys which relate to the station number primary key of the STATION relation. This is sensible since the STATION relation is the central relation.

Notice that by this definition foreign key relationships can't be designated between the LITHOLOGY and STRUCTURE relations. This rule is enacted specifically for managing referential integrity between the relations — it doesn't prevent LITHOLOGY and STRUCTURE from being related, say, in a query, but it does prevent them from being existentially dependent. Foreign keys are initially specified with this goal in mind, as they are declared solely for clarifying the nature of the existential dependence of the foreign key with its target relation. This is usually specified in terms of behaviour for inserting, updating, or deleting tuples from the database. For instance, when the value of a primary key is modified, should any related foreign key tuples

also be modified? If a primary key value is deleted should the tuples containing its foreign key values also be deleted?

Each of these questions may be typically answered by one of four action options: *restricts, cascades, nullifies* or *defaults*. The database operation could thus be *restricted* from occurring, it could *cascade* to the related tables, it could set to *null* the foreign keys in the related tables, or it could change the foreign key values to a pre-determined *default* value. For instance, altering a station number value (SITE_ID) in a tuple in the STATION relation could be responded to in one of the following ways by the related foreign keys:

- If identical station numbers exist in STRUCTURE or LITHOLOGY then the system prohibits alteration of the station number (*restricts*)
- If *cascades* is specified then the matching station numbers in the foreign key relations are also altered
- If *nullifies* is specified they are made null
- If a *default* value such as 'system' is specified they are changed to this default value

Similarly, when a station number is deleted from the STATION table, the options may specify that the operation is invalid if matching foreign key values exist, that all matching foreign keys are also deleted, or changed to null or a default value.

SQL handles these options through phrases that are incorporated into the definition of the relation: *on delete cascade, on delete set null, on delete set default,* and *on delete restrict*; as well as *on update cascade, on update set null*, *on update set default*, and *on update restrict.* A related, but somewhat different, constraint considers whether a foreign key can be null, that is, whether it's existentially dependent on the primary key. The SQL syntax incorporates the key words *not null* for this. For example, the SQL statements for creating the STATION, LITHOLOGY, and STRUCTURE relations would resemble the following:

e.g. for STATION (SITE_ID, X_LOCATION, Y_LOCATION, DATE) the statement is:

```
create table STATION
    (SITE_ID  integer not null unique,
    X_LOCATION integer,
    Y_LOCATION integer,
    DATE integer,
     primary key (SITE_ID));
```

e.g. for LITHOLOGY (SITE_ID, ROCK_ID, ROCK_TYPE, DESCRIPTION) the statement is:

```
create table LITHOLOGY
    (SITE_ID integer not null,
    ROCK_ID integer not null,
    ROCK_TYPE char (30) not null,
    DESCRIPTION char (250),
```

primary key (SITE_ID, ROCK_ID),

foreign key (SITE_ID) references STATION (SITE_ID)

on delete cascade on update cascade);

e.g. for STRUCTURE (SITE_ID, STRUCTURE_ID, FEATURE, AZIMUTH, DIP_PLUNGE, ROCK_ID) the statement would be:

create table STRUCTURE

(SITE_ID integer not null,

STRUC_ID integer not null,

FEATURE char(20) not null,

AZIMUTH integer,

DIP_PLUNGE integer,

ROCK_ID integer,

primary key (SITE_ID, STRUC_ID),

foreign key (SITE_ID) references STATION (SITE_ID)

on delete cascade on update cascade,

foreign key (SITE_ID, ROCK_ID) references LITHOLOGY (SITE_ID, ROCK_ID)

on delete set null on update cascade);

In this way relational databases bind related concepts and allocate appropriate behaviour to them.

Normalization

As noted above, decomposing a concept into multiple relations is performed for both conceptual clarity and efficient database design. More often than not these two directions coincide, as the theory of effective database design, called *normalization*, is founded on the inherent, semantic relationships within a set of data. In normalization, the relationships between data are expressed as *functional dependencies* and they may exist only within one relation, between attributes of the relation. During normalization, the functional dependencies within a relation may cause the relation to be further subdivided (normalized) into two or more derivative relations. An attribute set (i.e. one or more attributes) is functionally dependent on another attribute set in the relation if the presence of one set of attribute values in a tuple always coincides with the presence of the other attribute values. For instance, in the un-normalized table below, rock class is functionally dependent on rock type. Whenever ‘granite’ occurs in the rock type column, ‘plutonic’ occurs in the rock class column, or Rock Type-->Rock Class (Rock Type functionally determines Rock Class). Note that the opposite, Rock Class-->Rock Type, isn’t true because an instance of ‘plutonic’, for example, doesn’t necessarily yield ‘granite’, there being more than one type of ‘plutonic’ rock. Functional dependencies are transitive. For instance, if Site_id-->Rock Type and Rock_Type-->Rock_Class then Site_id-->Rock_Class.

Un-normalized...

site_id	x	y	rock_type1	rock_class1	rock_type2	rock_class2
1	100	100	granite	plutonic	dacite	volcanic
2	200	100	granite	plutonic	rhyolite	volcanic

table continued...

feature1	feat_class1	azimuth1	dip1	feature2	feat_class2	azimuth2	dip2
foliation	planar	200	20	foliation	planar	200	20
lineation	linear	300	30				

Figure B-5. An un-normalized table of field observations at two field sites.

Normalization is prompted by problems maintaining referential integrity within and between relations. For example, consider the un-normalized table in Figure B-5. From a design perspective, this table represents a novice's first attempt at organizing field data. The columns represent various field observation types and each row represents the data for a distinct field station. This design is attractive because it can be maintained in a single spreadsheet, however, it's problematic in many ways. To accommodate more than one type of structure or rock type at a station, multiple columns must be added to the table. Because the number of observations at a station is unpredictable, the table either needs infinite width or must be restricted to a fixed number of observations. For instance, the table above allocates space for two lithologies and two structures. Either option is problematic. A very wide table means many empty cells, which results in a bigger databases, degraded database performance, and is difficult to visualize and thus understand. A narrow table with limited columns, such as the one above, prevents important data from being included in the database. Furthermore, it can be semantically ambiguous. For example, are the foliations at station 1 hosted by the granite, the dacite, or neither? It also faces certain update inefficiencies. Reclassifying granites to 'granitic' requires a traversal of the complete table. *First Normal Form* fixes some of these problems.

1st Normal Form

site_id	x	y	rock_id	rock_type	rock_class	struc_id
1	100	100	1	granite	plutonic	1
1	100	100	2	dacite	volcanic	2
2	200	200	1	granite	plutonic	1
2	200	200	2	rhyolite	volcanic	

table continued....

feature	feat_class	azimuth	dip	srock_id
foliation	planar	200	20	1
foliation	planar	200	20	1
linear	linear	300	30	

Figure B-6. The un-normalized table of Figure B-5 arranged in 1st Normal Form.

Tables in first normal form (Figure B-6) can't contain repeating column types such as rock_type1, rock_type2, and so on. Multiple instances of a column type, such as rock type, are instead appended as new rows and common data are repeated in each row. For instance, each separate structural reading is recorded into a new row containing repeated station information, such as the station number and its location. The table thus grows in length instead of in width. This treats the most pressing problem of data loss, as 1st normal form doesn't impose limits on the number of data occurrences and thus permits all relevant data to be recorded. Furthermore, including identifiers for each lithology and structure at a station allows structures to be related to lithologies. For example, both foliation measurements at station 1 are hosted by the granite, and the lineation at station 2 isn't associated with any specific rock type. However, there is a lot of duplicate data with this design, which causes performance degradation and introduces several update and delete complications. For instance, modifying or deleting a station number or its location would affect several rows, as would re-classifying 'granites' to 'granitic'. Maintaining the relationship between structures and their host rock types is also complicated — if a rock identifier changes, its related structure must be updated. *Second Normal Form* addresses many of these issues.

2nd Normal Form

site_id	x	y
1	100	100
1	100	100
2	200	200
2	200	200

STATION table

site_id	rock_id	rock_type	rock_class
1	1	granite	plutonic
1	2	dacite	volcanic
2	1	granite	plutonic
2	2	rhyolite	volcanic

LITHOLOGY table

site_id	struc_id	feature	feat_class	azimuth	dip	rock_id
1	1	foliation	planar	200	20	1
1	2	foliation	planar	200	20	1
2	1	lineation	linear	300	30	

STRUCTURE table

Figure B-7. The un-normalized table of Figure B-5 arranged in 2nd Normal Form.

In second normal form a single table design can be decomposed into several tables, based on functional dependencies between its attributes. More specifically, second normal form tables are in first normal form and every attribute that isn't part of the primary key must be functionally dependent on the primary key. As discussed above, primary keys are one or more attributes that uniquely identify a row in the table. Consider the 1st Normal Form table of field observations. It yields the following functional dependencies:

site_id --> x, y

(site_id, rock_id) --> rock_type

(site_id, rock_id) --> rock_class since rock_type --> rock_class

(site_id,struc_id) --> feature, azimuth, dip, rock_id

(site_id,struc_id) --> feat_class since feature --> feat_class

From these functional dependencies it's clear that our 1st Normal Form table should be decomposed into three tables adhering to 2nd Normal Form. This decomposition is intuitive, as it should be, resulting in tables containing station, lithology, and structure data. Many of the previous update anomalies are overcome, largely due to the elimination of much redundant data and the introduction of foreign keys and referential integrity constraints between the tables (see the foreign key section above). For instance, deleting a station from the station table eliminates all lithologies and structures related to that station. Modifying a station number or rock identifier is also only performed once, with the changes propagated via foreign keys to any related tables. However, re-classifying granites to 'granitic' still requires the complete LITHOLOGY table to be traversed.

3rd Normal Form

3rd Normal Form overcomes this problem by disallowing attributes to be functionally dependent on the primary key via transitivity. In 3rd Normal Form, every attribute which doesn't compose the primary key must be non-transitively dependent on the primary key. This results in the following dependencies when applied to the 2nd Normal Form example above:

site_id --> x, y

(site_id, rock_id) --> rock_type

rock_type --> rock_class

(site_id,struc_id) --> feature, azimuth, dip, rock_id

feature --> feat_class

The following tables (Figure B-8) are generated from these dependencies:

3rd Normal Form

site_id	x	y
1	100	100
1	100	100
2	200	200
2	200	200

STATION table

site_id	**rock_id**	rock_type
1	1	granite
1	2	dacite
2	1	granite
2	2	rhyolite

LITHOLOGY table

rock_type	rock_class
granite	plutonic
dacite	volcanic
rhyolite	volcanic
etc...	

ROCK TYPE table

site_id	**struc_id**	feature	azimuth	dip	rock_id
1	1	foliation	200	20	1
1	2	foliation	200	20	1
2	1	lineation	300	30	1

STRUCTURE table

feature	feat_class
foliation	planar
lineation	linear
etc...	

STRUCTURE TYPE table

Figure B-8. The un-normalized table of Figure B-5 arranged in 3rd Normal Form.

It's comforting to see that normalization can lead to intuitive designs and that conceptual notions aren't necessarily distorted by relational requirements. There are at least three other normal forms: Boyce-Codd, 4th, and 5th. Boyce-Codd is useful when a relation has more than one primary key, each composed of more than one attribute, with at least one attribute shared between the keys. If this situation doesn't occur, Boyce-Codd is equivalent to 3rd Normal Form. The 4th and 5th Normal Forms address anomalies arising from dependencies among data that aren't functional but are related to multiple occurrences of values in the data and to joined tables. These last three normal forms are less frequently encountered. Generally, adherence to 3rd Normal Form suffices for many database designs.

Over-normalization

At times, adherence to normal forms can cause a database design to be overly decomposed. It's ultimately the designer (the domain expert) that must direct the level of normalization, balancing utility against complexity. For instance, we could include in our LITHOLOGY table an attribute listing the minerals noted in the rock type (Figure B-9). The one attribute may contain several mineral names:

site_id	**rock_id**	rock_type	Minerals
1	1	granite	bi-chl-qtz
1	2	dacite	plag-chl
2	1	granite	
2	2	rhyolite	

LITHOLOGY table

Figure B-9. A lithology table containing a Minerals field that can host multiple mineral names.

The functional dependency (site_id, rock_id) --> (rock_type, minerals) doesn't argue for segregating *minerals* into a separate table, though this could be a valid design decision. The semantic basis for maintaining a single table argues that each entry under *minerals* represents a distinct assemblage and not a composition of separate observations. From the alternate perspective, where each entry in the *minerals* column is an individual observation, as opposed to the totality of the assemblage, it may be wiser to create a MINERALS table (Figure B-10). In fact, if *minerals* isn't considered an assemblage, then the LITHOLOGY table above would be un-normalized as it would contain repeating values, albeit within a single column. In that case it should be decomposed:

site_id	**rock_id**	rock_type
1	1	granite
1	2	dacite
2	1	granite
2	2	rhyolite

LITHOLOGY table

MINERALS table

site_id	**rock_id**	minerals	percentage
1	1	biotite	10
1	1	chlorite	20
1	1	quartz	30
1	2	plagioclase	10
1	2	chlorite	20

Figure B-10. The Figure B-9 table normalized.

From this example it's evident that database design must reflect the semantic underpinnings of the subject area. In doing so, it's first necessary to determine what these semantic concepts are before arranging them into a database schema. The task of identifying relevant concepts and relations for inclusion in the database represents another aspect of database design.

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FieldLog's Database Design

FieldLog's Database Design

Underlying all FieldLog components and functions is a conceptual data model that consists of geologic concepts and their rules of interaction. The data model is an abstraction of the geological mapping process where concepts common to most geologic mapping activities are identified and their general relationships defined. In this sense the mapping process is grossly distilled to a series of commonly performed activities with common objects of observation. FieldLog provides this basic conceptual structure to the geologist and permits it to be

implemented by individuals in very different ways by refining and adapting the concepts into a personalized database definition.

Because FieldLog operates with a relational database, the data model's geologic concepts are translated into relational database constructs for data processing, which constitutes its logical design. Relational databases, and thus FieldLog, organize data in tables consisting of columns and rows. The data model is applied to this organization by classifying each table as a geologic concept (e.g. a site, a sample, an analysis, and so on) from the data model, and this classification causes the tables to inherit relational properties governing the database's behaviour.

In a table, columns represent types of data to be stored and the rows represent instances of those columns. For instance, a site table may contain columns containing the locations and site identifiers of field observations. Every occurrence of a site, with its accompanying identifier and location, would constitute a new row in the table. FieldLog requires the geologist to describe a field project as a set of tables containing columns. Each table is associated with a geologic concept from the data model. Once a table is registered with the model in this way, its interaction with other tables is established and thereafter exclusively handled by the data model. For example, operations required for extracting data from more than one table (relational joins), and for the inheritance of critical values between tables during data entry (for referential integrity) are maintained in a manner transparent to the geologist. For example, critical items such as site identifiers and sample numbers are propagated to all relevant tables until a new field site is established. Table types do have basic requirements. A sample table, for example, must possess columns containing site identifiers and sample numbers. Each table must also possess a numeric column whose row value is unique within the table and which acts as the link between the database and any graphic environment such as CAD or GIS. By insisting on certain key table elements, FieldLog is able to ensure that critical relational rules of behaviour are observed — that the database is relatively normalized (to third normal form) and that referential integrity is at least minimally maintained.

The conceptual model deals with spatial as well as semantic issues. Observed data originates from a geographic location which may be a region (outcrop) or a site (field station). Often these observations are made along a travelled path which defines a geographic route (traverse). In the course of a survey, sites and regions are encountered on one or more routes, and sites may occur within regions. Some observations are further defined by spatial partition (segment), often vertical, within their site or region of origin — a stratigraphic section at some field site, or a drill core segment within a drill hole. Once spatial positioning is accounted for, the relationships between observed data are semantic in nature as observers are discipline specific. Geologists observe rock, soil scientists observe soil, and biologists observe flora or fauna. These themes are generally described in terms of their composition (compose) or disposition (genesis), all of which may be sampled. Composition describes a theme's internal constitution, such as mineralogy or alteration within rocks, whereas disposition describes the theme in terms of its setting and the processes leading to its specific, often physical, configuration. Disposition may be described within a specific theme type or it may be macroscopic to the theme. For instance, structural processes display the following characteristic — it's possible to discuss

faulting within a rock type at a site, and also to discuss regional scale faulting which encompasses the site. All of themes (rocks), compositions (minerals), or dispositions (structures) may be sampled (sample). Samples may further undergo various analysis (analysis) such as geochemical, geochronological, petrographic, and so on. Themes, compositions, dispositions, samples, and analyses can be attributed to any spatial location, whether it's a site or partition within a site. Therefore, other than their vertical partitions, stratigraphic sections and drill hole segments can be described in the same general manner as non-partitioned sites or regions. This implies that field survey, drill hole, and stratigraphic section data can coexist within one semantic model, and also within a single database structure. FieldLog has indeed been often applied in these various situations.

Apart from observational data FieldLog also provides concepts to manage interpreted information such as geological boundaries (boundary), legends (legend) and units (unit). These interrelated concepts may further be associated to the field observations used to deduce them. Thus, reasonably thorough information about any geologic boundary can be maintained in FieldLog. Each boundary may be related to more than original field observation, by including the boundary identifier with the field observation. Successive boundaries may then in turn be related to a geologic unit, with the inclusion of a unit identifier in the boundary description. Both units and boundaries may be classified or described by a legend. The legend label must be included in the boundary or unit description to achieve this.

In addition to implementing geologic concepts FieldLog also permits customizable catalogs of geological terms to be created and attached to columns for data entry purposes and for the maintenance of semantic integrity of terminology. FieldLog implements such catalogs in two modes — as dictionaries (diction) and their profiles. A dictionary contains an archive of geological terms. It also contains a definition for each term, thus ensuring that a record of the semantic meaning of each term is maintained. A hierarchical arrangement of some dictionary items is called a profile and it's the profile which is attached to a column and presented to the geologist during data entry. Once a profile is attached, the contents of the column are restricted to items from the profile. It's possible to configure the column to accept single or multiple terms from the attached profile and multiple choices are recorded in their order of selection, so that terms may be arranged in priority sequence. Profile items may be assigned an abbreviation for rapid data entry, and may also be assigned custom symbology for visualization. A dictionary may be associated with many profiles, but a profile can only draw its items from one dictionary. Profiles permit personalized and project specific collections and arrangements of geological terms to be employed, yet also allow standard terminology in the form of dictionaries and their defined semantics to be defined within projects or agencies. Profiles and dictionaries can be modified at any time and can contain an unlimited number of terms. They are invaluable for data entry.

FieldLog furthermore presents two additional general utility tables —references (reference) and the miscellaneous category of other (other). Any non-dictionary table may contain a reference number which refers to material residing in a reference table. A FieldLog database may contain more than one reference table and it's up to users to select the appropriate reference table during querying and other operations. The remaining table category, 'other', permits tables to be incorporated into the model without conforming to FieldLog's general data

model. However, FieldLog doesn't allow these tables to be related to any other FieldLog table — they become stand-alone tables in the field database.

Thus FieldLog contains 15 primary concepts, which represent the range of table types manipulated by the system in the relational environment. A complete list of these types follows. Where the conceptual name differs from the logical, relational implementation, the logical name is enclosed in brackets: analysis, sample, composition (compose), disposition (genesis), theme (rock), partition (segment), site (station), region (outcrop), route (traverse), boundary, unit, legend, reference, dictionary (diction), and other. These are discussed in detail below.

Referential Integrity

FieldLog's logical table types are discussed below. Each table type is briefly described and relevant primary, foreign, and candidate keys are listed. Referential integrity constraints aren't specified, as FieldLog expects these to be defined within the host database environment. Referential integrity isn't specified during table creation in FieldLog as the acceptable syntax varies from one database system to another. FieldLog does, however, maintain many intra-table constraints such as attribute uniqueness, null values, defaulting, and so on., during its operations. Inter-table constraints such as update and delete actions are respected by FieldLog if specified within the database environment. For instance, when using an MS-Access database with FieldLog, referential integrity can be specified within MS-Access and is maintained for all FieldLog operations.

Functional Dependency and 3rd Normal Form

FieldLog's database model places each table into 3rd Normal Form — in fact, into Boyce-Codd Normal Form as well — by virtue of its general logical design. In this design users must select from within each table one or more attributes to serve as a primary key for the table. They can also select other attributes from each table and designate them as foreign keys, which must conform to some pre-defined foreign key options. In effect, FieldLog provides a relational framework that users may populate with personal choices. In doing so, every attribute in a table which doesn't compose the primary key is functionally, non-transitively dependent on the primary key. Each table contains a primary key, usually a composite key consisting of several columns, as well as a candidate key — the unique number — which is required for linking to maps and other GIS. However, because this candidate key isn't composite, Boyce-Codd normalization complications are avoided and each FieldLog table therefore by definition conforms to 3rd Normal Form. For example, consider the Sample relation:

SAMPLE (site_id, rock_id, sample_id, sample_type, sample_description, unique_id)

It can be related, via foreign keys to the station, segment, rock, boundary, unit, legend, and reference tables. Its primary key can consist of some or all identifiers from these same tables: station number, segment number, rock number, and sample number. For example, station 1001, 3rd rock type, 2nd sample. The critical functional dependencies for this example are:

(site_id, rock_id, sample_id) --> sample_type, sample_description

(site_id, rock_id, sample_id) --> unique_id

(unique_id) --> sample_type, sample_description

(unique_id) --> (site_id, rock_id, sample_id)

Clearly, every non-primary key attribute is functionally, non-transitively dependent on the primary key, and the relation is in 3rd Normal Form. Each of FieldLog's table types adhere to this general structure.

There's one final element of FieldLog which appears to contradict normalization. FieldLog allows users to permit multiple entries into a database column, particularly where a dictionary is attached. At first this seems to contradict the first rule of normalization. However, from the discussion above, these entries are semantically viewed as one item — see the minerals example in the normalization section above.

Geologic Influences and Relations

Finally, in the section below, all observational table types (analysis, sample, rock...) can be related to boundary and unit tables. This captures the sense that a field observation may critically determine, or influence, some interpreted entity such as a contact or unit. Similarly, most table types can be related to some legend entity, indicating they impacted the existence of that legend entity. For instance, a map polygon may be classified by a legend unit indicating that the polygon contributed to the establishment of the legend unit. In addition, every table type, except 'other', may contain a bibliographic reference.

The final possible relation is the grouping construct which associates two or more rows in a table. A column is specified as the grouping column and common values in that column, within a station, rock, sample, and so on, are considered a group by various FieldLog map operations. For instance, a station may contain many structural measurements, two of which are related — perhaps a lineation occurring on the plane of a foliation. These could be designated as belonging to a structural group within the station, thus defining the relation between them.

Indexing

To optimize data access, particularly querying, FieldLog uses indexing extensively (but only in AutoCAD R12; R13/R14 databases aren't indexed). Query operations are dominated by two basic operations: joining tables based on common attribute values and searching attributes for specific ranges of values. It's possible to predetermine indexes for the first of these events since the joining of tables during query operations, in FieldLog, must be based on the foreign key relationships between the tables — these are established during the setup phase, prior to using any table. Thus FieldLog indexes all primary and foreign keys, as well as the unique number used for linking the database to a map. Predicting which other attributes in the database need indexing is impossible, as queries are arbitrary. Therefore FieldLog restricts itself to indexing the key attributes.

FieldLog permits 15 different table types, which result in 11 possible foreign keys to relate tables: analysis number, sample number, rock number, segment number, station number, outcrop number, traverse number, boundary number, unit number, legend number, reference number and unique number. FieldLog therefore creates an index for the primary key and each foreign key in a table.

Indexes are named by including the table name as prefix and appending standard three letter suffixes for the different index types. For instance, a table named STATI (STATION) may contain outcrop and traverse numbers as foreign keys linking it to OUTCROP and TRAVERSE table types, respectively. FieldLog would create four indexes for this table: one for the primary key (STATIPRI), one for the unique number (STATIUNQ), and two for the foreign keys (STATIOUT, STATITRV). Note that each FieldLog table contains minimally two indexes, the first for the primary key and the second for the unique number. Indexes are named with standard suffixes, depending on the nature of the key. Because some foreign key attributes are incorporated into the primary key, and thereby automatically indexed, the number of indexes possible is less than the total number of foreign keys. For example, a SAMPLE table type would incorporate station, segment, rock and sample numbers into its primary key and index these columns once, as a part of the primary key. A list of the standard index suffixes follows:

primary key:	<table name> + 'PRI'
unique number:	<table name> + 'UNQ'
outcrop number:	<table name> + 'OUT'
traverse number:	<table name> + 'TRV'
boundary number:	<table name> + 'BND'
unit number:	<table name> + 'UNT'
legend number:	<table name> + 'LEG'
reference number:	<table name> + 'REF'

One last index type is FieldLog's 'memo' table index. Memo tables are tables ancillary to main database tables. They store free-format, unlimited length text which belongs to a column of the main database table. Memo table names and their index names are identical:

memo:	<table name> + 'MEM'

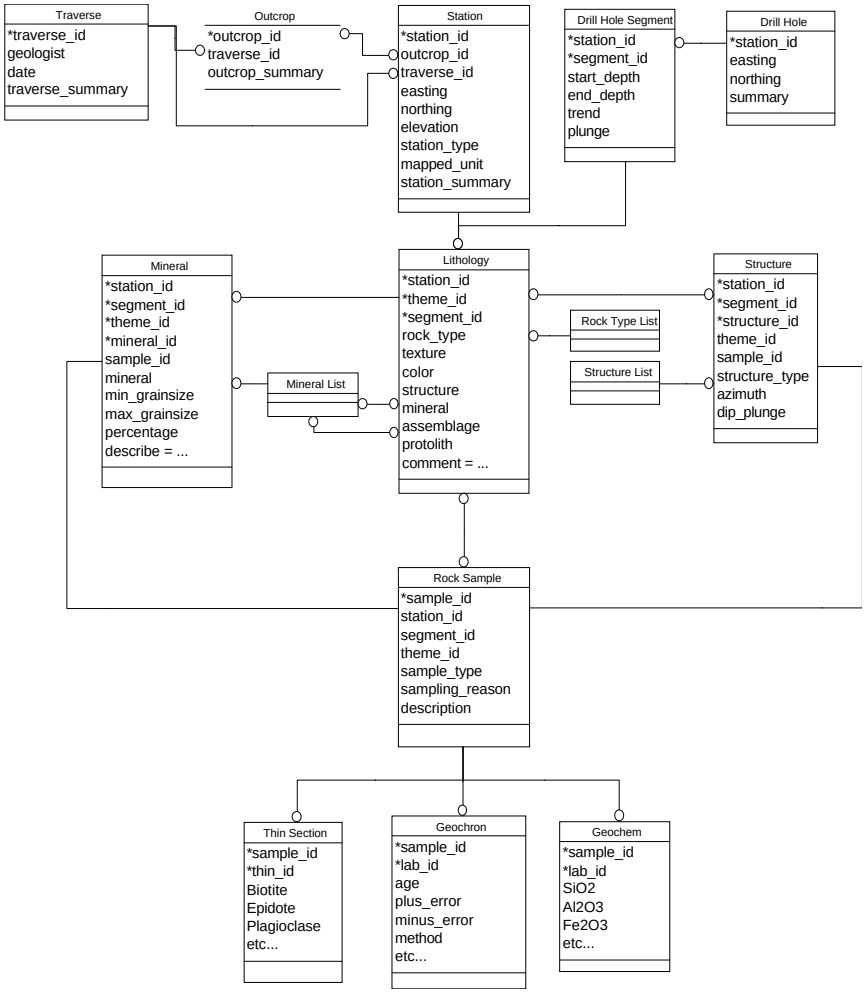

Figure B-11. A skeleton database design for geological field observations and drill hole observations. The mineral, rock, and structure lists represents catalogs of geological terminology.

Annotated Bibliography of GIS for Geologists

Introduction

This bibliography is a starting point for people interested in reading the literature on GIS and Geoscience data management. The bibliography lists papers and books of interest to someone who has collected data in the field and now wants to do something with it. The first section provides a list of papers and books, with notes on what they are about and why they might be interesting. The second section contains a list of readings that are recommended based on what you're trying to accomplish while learning about these methods. We've included some books that are inspirational, and some books from related fields (especially remote sensing) as related skills are essential in strong use of GIS.

This list was compiled by Rob Harrap, with suggestions from Boyan Brodaric. It's by no means complete, and we would welcome hearing suggestions (or complaints). This list lives on the web at http://geol.queensu.ca/harrap/robh.html and you should be able to find an updated version there.

WWW References

NADM WebSite: http://www.geology.usgs.gov/dm/

The North American Data Model is an attempt to provide a generic, flexible, and portable data model for field geology. The current version is based on the semantics of geologic data and on relational database theory. The NADM web page highlights current versions and ongoing research.

NCGIA Core Curriculum WebSite: http://www.ncgia.ucsb.edu/education/curricula/giscc/

The NCGIA maintains this resource site for teachers needing overview material to extend their courses on GIS. It provides fairly succinct coverage of most major issues in GIS.

Core Curriculum in RS WebSite: http://www.research.umbc.edu/~tbenja1/

The RSCC provides an overview of the main ideas in remote sensing, intended for practitioners who need teaching materials and a review of new topics. Many figures are included online for download.

Digital Chart of the World WebSite: http://www.maproom.psu.edu/dcw/

The Digital Chart of the World is a reference map of the major features on the globe. It includes human and natural features in separate GIS themes, at a nominal scale of 1:1 Million. The Penn State Map Room provides online access to the DCW in ArcInfo format.

National Geospatial Clearinghouse: http://mapping.usgs.gov/nsdi/

The NSDI provides online access and metadata for a huge variety of global and local GIS data useful in geologic mapping projects. It is a portal to remote sensing and GIS catalogues maintained by the USGS.

Papers

Baker, V.L.
1999: Geosemiosis; Bulletin of the Geological Society of America, v. 111, p. 633-645.

An interesting and controversial look at the philosophy of geology, based on the semiotic approach in cultural studies.

Bishr, Y.
1998: Overcoming the semantic and other barriers to GIS interoperability; International Journal of Geographical Information Systems, v. 12, p. 299-314.

Interoperability refers to the ability of multiple software systems to share access to data. In large projects this is a key issue in whether software tools really help an organization. Many of the issues deal with the semantics of data, as reviewed in this technical paper.

Brodaric, B. and Fyon, J.A.
1989: OGS FieldLog: A microcomputer-based methodology to store, process and display map-related data; Ontario Geological Survey Open File Report 5709, 73 p.

An early paper on FieldLog and what it can do. Read it to see how far FieldLog has progressed.

Broome, J., Brodaric, B., Viljoen, D., and Baril, D.
1993: The NATMAP Digital Geoscience Data Management System; Computers and Geosciences, v. 19, p. 1501-1516.

A team review by staff at the Geological Survey of Canada, this paper summarizes the data flow and cartographic process at the Survey and points out key problems in data management in a large organization.

Burrough, P.A.
1992: Are GIS Data Structures Too Simple Minded?; Computers and Geosciences, v. 18, p. 495-400.

Real world data and GIS data models are not always a good match. Why this is so and what can be done about it is the topic of this classic paper.

Carver, S., Heywood, I., Cornelius, S., and Sear, D.
1995: Evaluating field-based GIS for environmental characterization: Modelling and Decision Support; International Journal of Geographical Information Systems, v. 9, p. 475-486.

A technical look at the use of GIS in environmental evaluations.

Cheng, T. and Molenaar, M.
1999: Objects with Fuzzy Spatial Extent, Photogrammatic Engineering and Remote Sensing; v. 65, p. 797-801.

Real world objects are not as well delimited or clearly characterized as we would often like to think when building GIS datasets. Fuzzy logic is one way to address these issues.

Currie, A. and Ady, B.
1990: GEOSIS Project: Knowledge Representation and Data Structures for Geoscience Data in Statistical Applications: in Statistical Applications in the Earth Sciences; (ed.) by Agteberg, F.P. and Bonham-Carter, G.F., Geological Survey of Canada, Paper 89-9, p.111-116.

A classic early attempt to integrate hierarchical domains, as used in FieldLog, into GIS projects in the geosciences.

Egenhofer, M.
1992: Why not SQL!; International Journal of Geographic Information Systems, v. 6, p. 71-85.

The underlying data language used to express queries in a GIS places real limitations on what can be done. This quite technical paper addresses SQL, the standard database query language, and its limitations.

Frank, A.U.
1992: Spatial Concepts, Geometric Data Models, and Geometric Data Structures; Computers and Geosciences, v. 18, p. 409-417.

A thorough review of data models as used in GIS, with an excellent reference list attached.

Frodeman, R.L.
1996: Envisioning the Outcrop; Journal of Geoscience Education, v. 44, p. 417-427.

A review of the philosophical issues in field data collection, from a philosopher who went back to school to study geology.

Gahegan, M.
1997: The Visualization of Relationships Between Geographic Datasets; Proceedings of Geocomputation 1997 and SIRC 1997, p. 335-343.

This paper presents an attempt to look at the complex relationships in geographic data using visualization tools in 2d and 3d. Although fairly academic, the kinds of approaches here will show up in the next generation of GIS tools on the market.

Goodchild, M.F.
1992: Geographic Data Modelling; Computers and Geosciences, v. 18, p. 401-408.

We don't only collect data, we then do something with it. The analysis that follows data collection is the topic of this paper.

Krige, D.G.
1999: Essential basic concepts in mining geostatistics and their links with geology and classical statistics; South African Journal of Geology, v. 102, p.147-151.

A review of the concepts of geostatistics including comments on validation and biases. Geostatistical tools are key requirements in effectively using sampled data such as geochemical and geophysical measurements.

Laxton, J.L. and Becken, K.
1996: The design and implementation of a spatial database for the production of geological maps; Computers and Geosciences, v. 22, p. 723-33.

A review of the attempts at the British Geologic Survey to build a system for constructing and disseminating geologic maps. Examines the issues in digitizing and cartography in detail.

Milne, P., Milton, S., and Smith, J.L.
1993: Geographical Object-Oriented Databases – A Case Study; International Journal of Geographic Information Systems, v. 7, p. 39-55.

Object oriented databases offer particular strengths to geological work. This early technical paper on OODBMS in GIS sets the stage for current research.

Newell, R.G., Theriault, D., and Easterfield, M.
1992: Temporal GIS – Modelling the Evolution of Spatial Data in Time; Computers and Geosciences, v. 18, p. 427-33.

Handling time in a GIS is tricky, and this paper looks at some of the key problems.

Nyerges, T.L.
1991: Geographic Information Abstractions: Conceptual Clarity for Geographic Modelling; Environment and Planning A, v. 23, p.1483-1499.

This paper discusses the issue of abstraction in GIS, including classification, generalization, and aggregation issues. It delves into the philosophy of GIS modelling, including temporal models and the nature of geographic reality.

Raper, J.F. and Maguire, D.J.
1992: Design Models and Functionality in GIS; Computers and Geosciences, v. 18, p. 387-394.

How we organize projects and databases, and what functionality is built into software systems, is the topic of this review paper.

Schetselaar, E.
1995: Computerized Field-Data Capture and GIS Analysis for Generation of Cross Sections in 3-D Perspective Views; Computers and Geosciences, v. 21, p. 687-701.

An overview of the construction of geologic sections from field data, including data collected with systems like FieldLog.

Webster, T.L., Murphy, J.B., and Barr, S.B.
1998: Anatomy of a terrane boundary: an integrated structural, geographic information system, and remote sensing study of the late Paleozoic Avalon-Meguma terrane boundary, mainland Nova Scotia, Canada; Canadian Journal of Earth Science, v. 35, p. 787-801.

A good example of the kind of large-scale thinking that can be done with GIS and remote sensing. Excellent examples of visualization output from a GIS.

Books

Most of these are texts (we've indicated those that are research volumes in the notes) and are in general more readable than the papers. On the other hand, with the exception of Bonham-Carter's excellent text, these are for the most part geographic and computer oriented rather than addressing concepts of direct interest to geological applications.

GIS

Longley, P.A., Brooks, S.M., McDonnell, R., and Macmillan, W.
1998: Geocomputation; John Wiley and Sons, New York, New York, ISBN 0-471-98575-9, 278 p.

[Research Level Book] A collection of papers on computation with geospatial data. Not specifically geological, and transcends GIS to talk about spatial data in general. Interesting as a view on what the current research directions in spatial computing are.

Borrough, P.A. and McDonnell, R.A.
1998: Principles of Geographical Information Systems; Oxford University Press, ISBN 0-19-823365-5.

A very solid introduction to GIS and some aspects of spatial statistics. Key features are a solid treatment of error analysis, fuzzy set approaches to GIS, and a detailed overview of interpolation techniques.

Laurini, R. and Thompson, D.
1992: Fundamentals of Spatial Information Systems; Academic Press, ISBN 0-12-438380-7, 680 p.

[Research Level Book] Everything you never wanted to know about the internal workings of GIS, including both advanced raster techniques and vector techniques. This is not a book about USING GIS, as much as a book about how the GIS works. A good book for finding out what is going on behind the scenes.

MacEachren, A.M.
1995: How Maps Work: Representation, Visualization, and Design; Guilford Press, ISBN 0-89862-589-0

[Research Level Book] This book is as much about how we see maps as it is about how maps are physically made, whether by computer or hand. While it won't directly teach you about GIS data structures and such, it will make your maps much clearer. Unique and very challenging due to the breadth of issues covered, from neural aspects of perception to map symbolization to GIS.

Monmonier, M.
1991: How To Lie With Maps; University of Chicago Press, Chicago, Illinois, ISBN 0-226-53415-4.

A very readable guide to intellectual self defence in map interpretation and analysis. Not specifically a GIS book, but a key guide to understanding how maps may be used to mislead.

Peuquet, D.J. and Marble, D.F.
1990: Introductory Readings in Geographic Information Systems; Taylor and Francis, ISBN 0-85066-856-5.

A collection of wide ranging references on GIS, divided into background, practical applications, and more theoretical design and evaluation sections. The practical applications section is somewhat dated, but the other sections are still classics in the fundamentals of GIS. The book is similar to a textbook in scope, but in self-contained paper form.

Jones, C.
1997: Geographical Information Systems and Computer Cartography; Longman. ISBN 0-582-04439-1.

A wonderful, compact, overview of all aspects of GIS and cartographic systems, ranging from the basic to the very advanced. Readable, useable, accessible. Limited number of color plates keeps the price down, but limits what can be shown in remote sensing sections.

MacEachren, A.M.
1994: SOME Truth with Maps: A Primer on Symbolization and Design; Association of American Geographers, ISBN 0-89291-214-6 (order from AAG, 1710 16th St. Washington, D.C.20009-31980.

A classic, small, readable introduction to making presentable and accurate maps using GIS. Much of the material is adapted from traditional cartography, but in a way that highlights how GIS tools fit in. This is a 'how-to', not a theory book (see instead MacEachren's How Maps Work) nor a case study book (see instead Tufte's Envisioning Information).

Vincent, R.K.
1997: Fundamentals of Geological and Environmental Remote Sensing; Prentice-Hall, 0-13-348780-6.

[Research Level Book] By the time you get to the midpoint of this book, you will know more about the physics and engineering of remote sensing systems than you thought possible. And then come the case studies, which illustrate the application of multiband remote sensing data to geological exploration (kimberlite, precious and base metals, and oil) and environmental monitoring. Very good, reasonably complete, affordable one-stop-shopping for a remote sensing book.

Unwin, David.
1981: Introductory Spatial Analysis; Methuen, ISBN 0-416-72200-8, 212 p.

A mathematical treatment of map relationships, but quite accessible and relatively inexpensive.

Geology Specific

Agterberg, F.P. and Bonham-Carter, G.F.
1989: Statistical Applications in the Earth Sciences; Geological Survey of Canada Paper 89-9, ISBN 0-660-13592-2, 588 p.

This volume is as much about geostatistics as it is about GIS itself. A good collection of papers to look through if you are interested in the full range of spatial techniques from GIS to geophysical image interpretation to geostatistics.

Bonham-Carter, G.F.
1994: Geographic Information Systems for Geoscientists: Modelling with GIS; Pergamon, Tarrytown, New York, ISBN 0-08—42420-1, 398 p.

This is the only real GIS book that focuses on geoscience issues. It gets into the math very quickly, and focuses on modelling to find ore deposits, but the introductory material is also good. This book is well suited to be a ‘second’ book on GIS – in other words, read after you have read an introductory book on GIS (such as Jones’ book, for example).

De Paor, D.G.
1996: Structural Geology and Personal Computers; Elsevier, ISBN 0-08-043110-0.

A collection of papers covering a wide range of data collection, presentation, and analysis topics. Particularly useful for structural geologists, but also a good overview of communications/hypermedia efforts and mapping tools.

Drury, S.
1993: Image Interpretation in Geology; Chapman and Hall, London.

Sooner or later you will need to integrate airphoto information or perhaps even remote sensing data into your work. Drury provides a clear overview of geologic features as they manifest in imagery.

Gunther, O.
1998: Environmental Information Systems; Springer-Verlag, ISBN 3-540-60926.

A very interesting but very odd book. Gunther sets out to lay a framework for systems that manage environmental data, and really doesn't pull it off. The interesting thing is that the book is still quite useful. There is too little GIS for this to be a GIS book, and the rest covers subjects as diverse as object oriented database systems and modelling, metadata management systems, and the semantics of environmental data. All of the sections are clear, informative, and useful, but somehow they just don't seem to add up to a book with the title Environmental Information Systems.

Koch, G.S. Jr. and Link, R.F.
1971: Statistical Analysis of Geological Data; Dover, New York, New York, ISBN 0-486-64040-X, 438 p.

A thorough, somewhat mathematical treatment of all aspects of geologic statistics. Not particularly accessible, but complete. The section on geological statistics on computers is amusingly dated.

Computer Science, Mathematics, and Philosophy

Adriaans, P. and Zantinge, D.
1996: Data Mining; Addison Wesley Longman, Harlow, U.K., ISBN 0-201-40380-3, 159 p.

Data mining is the task of finding relationships in very large databases. Many of the methods are similar if not identical to those used in mainstream GIS, and in fact there is an increasing convergence between the three fields of machine learning, GIS, and data mining. This book is a short and readable introduction to the core concepts of data mining, many of which can be directly used in GIS analysis.

Ahl, V. and Allen, T.F.H.
1996: Hierarchy Theory: A Vision, Vocabulary and Epistemology; Columbia University Press, ISBN 0-231-08481-1.

A wonderful, to-the-point look at hierarchical systems, their role in science, and their behaviour. To me, this rates with Kuhn’s Structure of Scientific Revolutions

for laying very general and overarching rules for how human understanding in science works.

Brooks, F.
1995: The mythical man month, Anniversary Edition; Addison Wesley, ISBN 0201835959, 336 p.

If you are 'doing' computer work, as opposed to thinking about it, this book is an essential read. Brooks discusses the art of running a software development team, and dispels many notions that at first seem like common sense but in fact are incorrect – like the common assumption that adding programmers to a team will speed up development. Although there are newer books on this subject, this one cuts to the core, is readable, and doesn't wander off into jargon and businesspeak.

Cleveland, W.S.
1993: Visualizing Data; Hobart Press, Summit, New Jersey, ISBN 0-9634884-0-6, 360 p.

A statistical graphics book that lays out standards of good statistics and design. Statistical graphics are very common in GIS, and statistical arguments are at the core of many research applications of GIS in the geosciences.

Date, C.J.
1995: An Introduction To Database Systems, Sixth Edition; Addison-Wesley, Reading, Massachusetts, ISBN 0-201-54329-X, 839 p.

[Research Level Book]. The classic reference on relational database theory, design, and applications. Definitely not a light read! Probably not a good 'first book' on databases but definitive.

Foley, J.D., Van Dam, A., Feiner, S.K., and Hughes, J.F.
1990: Computer Graphics: Principles and Practice, Second Edition; Addison-Wesley, ISBN 0-201-12110-7.

[Research Level Book] A classic, encyclopedic reference on theoretical and practical issues in photorealistic computer graphics. The book is very clearly written, and explains all of the fundamental concepts and methods that GIS systems exploit. The overall aim of this book is more towards realistic scene building rather than interactive graphics, but the overall coverage is so good that the book remains a very good reference.

Huff, P.
1954: How to Lie with Statistics; Norton and Company.

The classic reference to the deliberate and accidental lies that statistics can generate. Very short and readable, and a good companion to Monmonier's follow-up, How to Lie with Maps.

Norman, D.A.
1993: Things That Make Us Smart: Defending Human Attributes in the Age of the Machine; Addison-Wesley, ISBN 0-201-58129-9.

Norman is one of the parents of the Cognitive revolution in psychology, and a very clear writer on how information and structure in the real world interacts with the mind to

produce confusion and chaos. What a tool is, and what data is, requires an understanding of what humans are and are not, and what limitations they have. A glorious book.

Phillips, J.L.
2000: How To Think About Statistics, Sixth Edition; W.H. Freeman & Company, New York, New York, ISBN 0-7167-3654-3, 202 p.

Statistics is at the core of GIS analysis and this is a good introduction to the fundamental ideas of statistics. The treatment is highly descriptive, and the reasoning aspect is emphasized.

Rumbaugh, J., Blaha, M., Premerlani, W., Eddy, F., and Lorenson, W.
1991: Object Oriented Modelling and Design; Prentice Hall, Englewood Cliffs, New Jersey, ISBN 0-13-629841-9, 500 p.

[Research Level Book] A very good, detailed introduction to object modelling and design, both for those doing object-oriented programming and for those working with object databases. Technically challenging, but an important foundation for serious programmers and designers.

Sowa, J.F.
2000: Knowledge Representation: Logical, Philosophical, and Computational Foundations; Brooks/Cole, Pacific Grove, California, ISBN 0-534-94965-7, 593 p.

[Research Level Book] Knowledge Representation is the subset of Artificial Intelligence research that deals with how we can store, visualize, and manipulate representations of real world knowledge in a computer. The object oriented programming movement is a direct result, for example, of research on knowledge representation in simulation languages carried out in the 1960s. This book is a thorough introduction to the history and methods of knowledge representation, especially to graph based methods. A very difficult read, but essential for those interested in the philosophical underpinnings of data modelling, reasoning, and advanced analysis.

Stefik. M.
1995: Introduction to Knowledge Systems; Morgan Kaufmann, San Francisco, California, ISB-155860-166X.

[Research Level Book] An exhaustive, clear, and essential guide to representing knowledge in any form, and in particular, to representing knowledge using computer systems. The coverage of symbol systems, representation, and semantics are the best I've read, and the well-reasoned examples illustrate the technical material very well. Knowledge Systems are to GIS' what GIS is to CAD - the next evolutionary step, and the challenge of building a meaningful geoscience information system, as opposed to a confused one, is well aided by books such as this one.

Teory, T.J.
1988; Database Modelling and Design: The Fundamental Principles, Second Edition; Morgan Kaufmann, San Francisco, California, 277 p.

[Research Level Book] A solid reference on database modelling methods, for those who do this regularly and need to know the details.

Graphic Design

Tufte, E.R.
1990: Envisioning Information; Graphics Press, Cheshire, Connecticut.

This book is an absolute classic, and perhaps the most cited book in graphic design and cartography of the last decade. Using hundreds of examples from past centuries, Tufte covers all aspects of making clear and informative graphics and maps.

Tufte, E.R.
1983: The Visual Display of Quantitative Information; Graphics Press, Cheshire, Connecticut.

Tufte's first book is not strictly about spatial graphics, but it is a classic in illustrating techniques for making graphs and charts clear and informative.

Tufte, E.R.
1996: Visual Explanations; Graphics Press, Cheshire, Connecticut.

Tufte's latest book, and most ambitious, is an attempt to look at what defines understandability in information graphics. A source of inspiration for thematic diagrams more than a directly applicable book on cartography or map design, the book is beautifully laid out and written.